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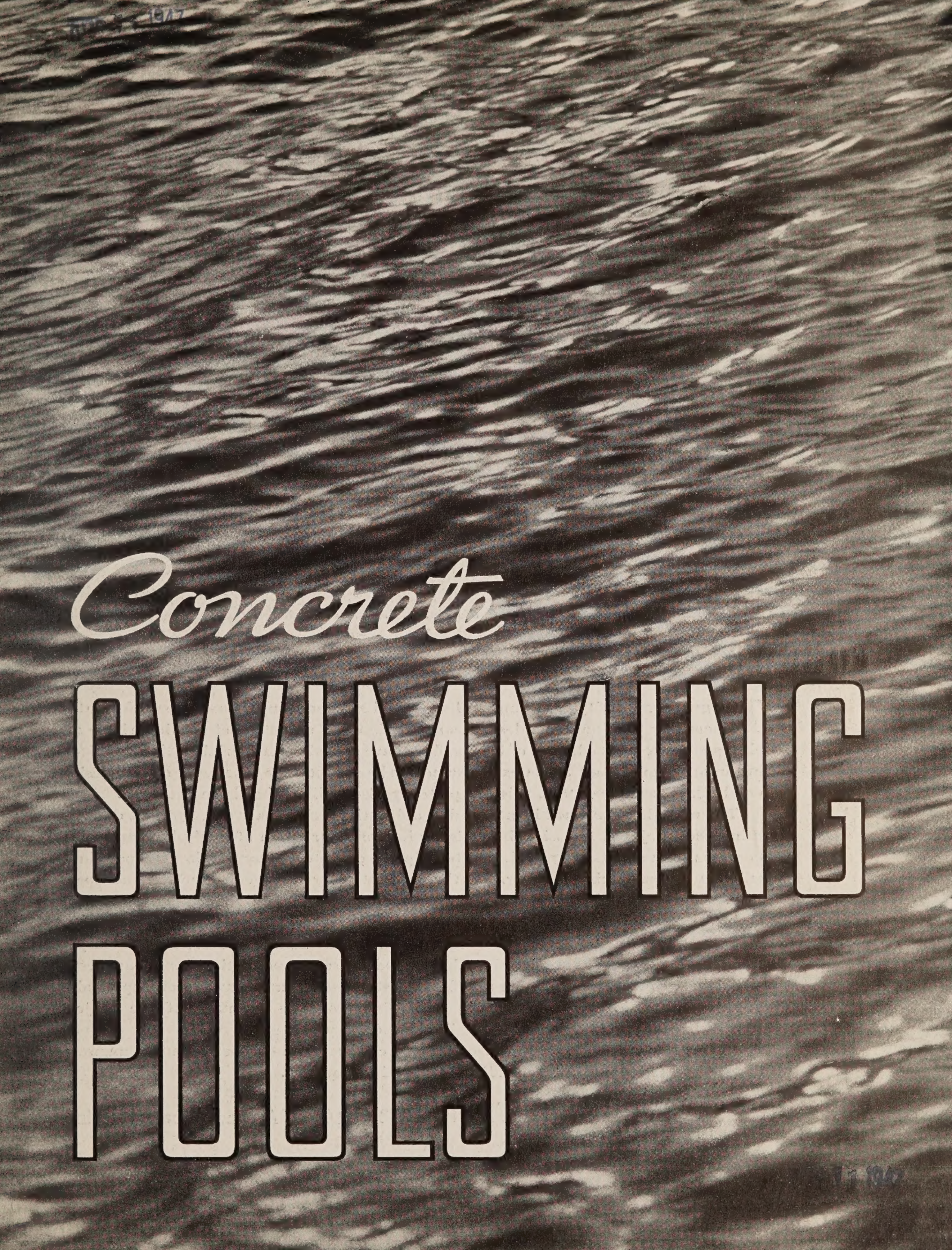

Concrete
SWIMMING POOLS

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Riverside Baths, Sacramento, California. W. E. Coffman, architect.

FOREWORD

THE great popularity of swimming has caused an increasing demand for information concerning the financing, design, construction and operation of public, private and club pools. Previous editions of this booklet have contained material on these subjects, but in order to present the latest information based upon the experience of pool designers, builders and operators, this completely revised edition has been prepared.

The material contained is intended to aid in the preliminary development of swimming pool projects, to assist the designer in the preparation of final plans and specifications for a satisfactory pool, and to help the operator in conducting the pool in an efficient and profitable manner. For the greatest economy in construction and operation, the design and construction of each pool should be under the supervision of an architect or engineer experienced in such work.

Some of the information given is of a general nature because the individual pool must be considered as a special problem, and all recommendations and data, especially those concerning planning and financing, cannot be made universally applicable. Supplementary information relative to specific problems on many of the subjects treated broadly in this booklet is available upon request.

If you have questions on swimming pool construction or operation not answered in this booklet, write us. We shall be glad to be of service.

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The activities of the Portland Cement Association, a national organization, are limited to scientific research, the development of new or improved products and methods, technical service, promotion and educational effort (including safety work), and are primarily designed to improve and extend the uses of portland cement and concrete. The manifold program of the Association and its varied services to cement users are made possible by the financial support of over 60 member companies in the United States and Canada, engaged in the manufacture and sale of a very large proportion of all portland cement used in these two countries. A current list of member companies will be furnished on request.

CONCRETE SWIMMING POOLS

Financing, Design, Construction and Operation

INTRODUCTION

A SWIMMING pool is an investment in health and happiness. Swimming has long been considered one of the most healthful and beneficial sports. Ancient Romans believed that a long daily swim was the best cure for insomnia! Early French monks believed it the best tonic for body and soul! Present-day physicians also believe in the benefits of swimming. The contribution of swimming in aiding the treatment of infantile paralysis victims is known to all.

Swimming under proper conditions is healthful, but under bad conditions may subject the individual to hazards of disease and accident. With the concentration of population, the water of the "old swimmin' hole" has, in many cases, become unfit for swimming. The new pool with its modern water purification system eliminates the danger of the spread of disease. The carefully designed and operated pool also removes the accident hazards inherent in the unsupervised swim in the river, lake, or quarry.

Adequate swimming facilities encourage beneficial exercise and tend to diminish juvenile delinquency by providing a positive influence for good.

It is the duty of public officials to protect the health and welfare of the public. Inasmuch as modern swimming pools aid in these functions, the officials responsible for their construction will receive the thanks of the public.

A swimming pool attracts non-residents, resulting in more business for local merchants.

To the club a swimming pool offers an increase in membership, club activities and income. Many country clubs have proved conclusively that a new swimming pool has been responsible for an increase in membership. Activities have been increased not only by the addition of new members but also by old members and their families spending much more time at the club while one or all use the swimming pool. Members who formerly came only for a round of golf now bring the family, have a swim, and stay for dinner. The first year the pool was in operation at one golf club, the dining room and bar showed the first profit in the history of the club, rather than the usual deficit which had been as high as $4,000 a year. The importance to the younger members of the family of providing healthful recreation in good environment must not be overlooked.

A swimming pool provides an ever-ready supply of water which would be extremely valuable in case of fire. This water can be used by a fire department pumper or, at a slight cost, an auxiliary pump may be provided to furnish pressure at convenient hydrants.

The private swimming pool adds distinction to the home, brings pleasure to the family and makes the home the center of healthful activity. For the residence away from the city water supply, the pool also provides fire protection.

Hotel owners find that a swimming pool attracts guests. It appeals to those who enjoy strenuous exercise, to those who would while away idle hours, to the bored and the sophisticated, and to the masses who simply enjoy swimming. Even where the hotel is located on a natural body of water, a swimming pool will prove popular because of the purity of the water and the clean and attractive surroundings.

THE PROJECT

A swimming pool should be considered as an integral part of a complete development. This applies to the small private pool as well as to the large municipal pool although all the factors are not the same. To obtain best results, it is necessary that the whole project be under supervision of someone experienced with such developments and that under his direction the parts of the plan be developed by specialists.

Ordinarily there will not be much question as to whether the pool will be indoor or outdoor. Where this question does arise, some of the points to be considered are: length of outdoor season compared to all-year use; desire to swim in open during summer; comparative cost of indoor and outdoor pools of same capacity; additional cost of operation during winter.

A complete development for a public swimming pool should include, in addition to the swimming pool or pools, a wading pool, bathhouse, spectator facilities, and play area.

Wherever possible, a wading pool should be included

The drawings in this publication are typical designs and should not be used as working drawings. They are intended to be helpful in the preparation of complete plans which should be adapted to local conditions and should conform with legal requirements. Working drawings should be prepared and approved by a qualified engineer or architect.

with every public or semi-public pool. For the sake of safety, the wading and swimming pools should be completely separated either by a fence or by a considerable ground area.

The bathhouse, of course, is an important part of a swimming pool project. The success of the development will depend in no small part upon a satisfactory bathhouse, which is discussed on page 20.

Adequate provision should be made for spectators. Their presence may form an extra source of revenue by collection of a small spectator fee or may simply be considered as advertising and good-will development. Suggestions for these facilities are given on page 20.

Many people want some type of entertainment between swims. The pool will prove much more popular if a play area is provided. If space and funds are available, it is wise to furnish facilities ranging from simply an area for sun bathing to the strenuous sports. The play area, in addition to its drawing power, will have the effect of increasing the pool capacity by keeping more people busy outside the water.

Sun bathing is very popular and should be encouraged by suitable facilities. The easiest construction to provide and maintain is simply a concrete-paved area. This may be terraced so that the sun bathers can have a better view of the pool. Sand areas are quite popular, but must be carefully maintained to keep them sanitary and attractive. The use of a coarse sand with an adequately drained concrete slab underneath will assist in keeping the sand in good condition. Most operators and health authorities insist that the sand area be separated from the pool and that a shower be taken when returning to the pool area. To be effective, the showers must discharge a large volume of water. Grass areas are even more difficult to maintain than are sand areas and should not be considered except for private pools.

Games which can easily be used in connection with swimming pools and offer wide variety of physical activities include: outdoor checkers, shuffleboard, paddle tennis, badminton, handball, tennis, basketball and weight lifting. A concrete dance floor with a coin operated record player is also popular and income producing*.

In a large part of the country, the outdoor pool cannot be used for swimming during several months of the year. Where there is a long period of freezing weather, the larger pools may be used for ice skating. In the non-swimming season, pools may be used for roller skating and various games such as those suggested for game areas. Large wading pools and the swimming pool of multiple-unit pools are particularly well adapted to these extra uses. Such multiple use of swimming pool facilities is especially desirable because it takes advantage of a fixed investment and extends its usefulness.

An indoor pool can be used the year around for swimming but, in addition, it may have a movable floor so that the entire pool room can be used as an exhibition hall such as that in the Earl's Court Exhibition Building, England. Other pools in England have been constructed so that part of a large outdoor pool is enclosed for winter use. Another method of making dual use of facilities is the construction of a large outdoor pool and a smaller indoor pool using the same water treatment plant and dressing facilities.

The outdoor pool will require more room for dressing facilities than the smaller indoor pool. In winter the extra dressing space may be used by patrons of the gymnasium, if such is included. If there is no gymnasium, the excess space may be turned into a recreation room or small gymnasium.

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*References are made in footnotes throughout this booklet to other publications issued by the Portland Cement Association containing additional pertinent information which will be sent free upon request in the U. S. and Canada. Information on play court construction is available.

Fire protection is the primary purpose of this reservoir at New Orleans Airport. Designing water reservoirs as swimming pools makes them serve a double purpose.

FINANCING*

Public Pools

There are many ways of financing public pools. Popular sentiment is generally so strongly in favor of the improvement that little difficulty is experienced in securing the money necessary for construction. A properly designed and operated pool is not a drain on the public treasury. By charging reasonable fees, the pool may be not only self-supporting but self-liquidating, if desired. This subject is discussed more fully on page 24.

Public pools are ordinarily constructed and managed by the park board of the city government. General funds of such bodies are sometimes sufficient for the construction of the pool, while in other cases general bonds may be issued. In some states, revenue bonds can be issued for such projects. These bonds are simply a lien on the income from the pool.

Where all the necessary capital cannot be obtained from park or city sources, all or part may be raised by public contribution. Labor, equipment, materials and professional services, as well as cash, are frequently donated. Thus, everyone can help and the task of raising funds to build the pool is minimized.

This view of Astoria Park swimming pool shows how New York City Department of Parks uses large pools during non-swimming months for games such as basketball, paddle tennis, handball and shuffleboard.

Civic clubs, chambers of commerce, and American Legion posts throughout the country have conducted many successful campaigns for community swimming pools. Sometimes several of these organizations have combined to conduct the campaign. They have thus rendered a valuable service to their community in contributing to the welfare and pleasure of its citizens.

This self-supporting municipal pool at Washington, Indiana, includes a sand beach separated from the swimming and wading pools by a fence and open air shower. John H. Kretz, architect.

Public campaigns may be conducted to secure outright donations, or to sell advance admissions in some form. Where donations are solicited, most of the funds will be obtained from a relatively small number of people. If admissions, reduced rates, or other inducements are offered, a great many more people will respond to the appeal for funds.

While funds for pool construction can be raised by sale of advance admissions, the problem of operating expenses must not be overlooked. The advance sale, of course, means that regular day-by-day receipts will be materially reduced and that some special provision must be made for operating expenses during the time advance tickets are being redeemed. If income from the pool is intended only to pay part of the expenses, the admission fees during the first year may be made somewhat higher than considered necessary in later years after expiration of the tickets sold in advance. If the pool is to be self-liquidating, payments on the principal may be set to begin after the advance tickets have expired.

Various benefits sponsored by the committee or other organization may comprise part of the public campaign to raise funds. These may include all sorts of athletic events, theatrical performances, concerts and exhibitions.

In some instances where public funds were not available, pools have been built by private capital with the understanding that they were to become public property after a certain number of years or after the pool had made certain returns to the builders. With such an arrangement, pools can be built on public land, thus reducing the private capital needed and permitting the public to own and control the pool at an earlier date.

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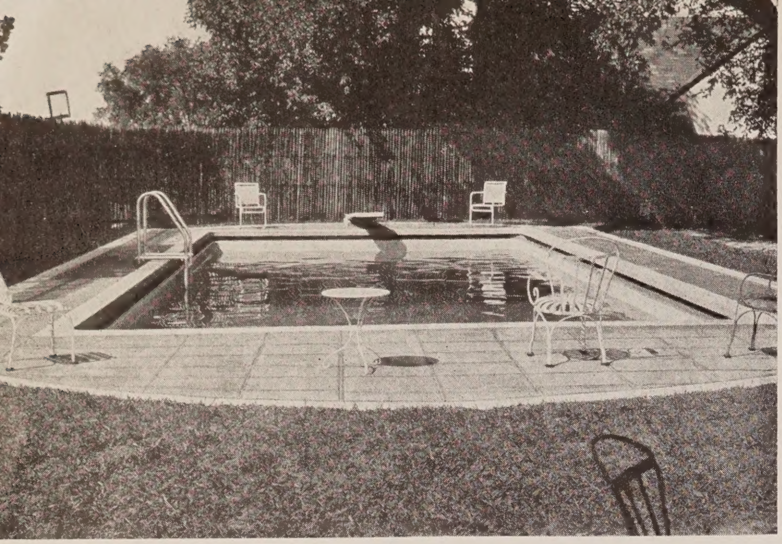
*Examples of cost, operating expenses, and returns are available free in U. S. and Canada on request.



A quiet, secluded pool owned by the designer, Edward Honnert, Cincinnati, Ohio.

Club Pools

Club pools may be built with funds from the general treasury or by bonds secured by the entire club. However, such general club funds are usually not available and it may be difficult to finance construction by a general bond issue. The most common practice is to form and incorporate within the club a Pool Association which will handle financing, construction and operation of the pool until finances are such that the project can be completely taken over by the club.

In order for the Association legally to build and operate the pool, it is customary for the two organizations to have a contract which includes the interrelation of the two and the leasing of the ground for the pool to the Association.

The Association may finance the pool in whole or in part by a bond issue. If the bonds are for only a small part of the cost, they may be sold through banks or other ordinary financial channels. If the bonds represent the major cost of the pool, it will probably be necessary to sell them to members of the club. Bonds should be subject to retirement as fast as income will permit. It will often be necessary or desirable to offer some special inducement to purchasers of bonds, such as an option on club memberships at a specified fee during a certain number of years.

Another method of raising funds is by the sale of memberships in the Pool Association. Such memberships are ordinarily limited to members of the club, but under some circumstances are extended to outsiders with certain restrictions. Memberships entitle the holders to use of the pool at reduced rates for a specified number of years.

Season tickets are also a common method of obtaining funds for club pools as well as public and commercial pools. With this method, provision must be made for operating expenses if the cash daily admission fees are not expected to cover them.

SELECTION OF SITE

The general location of a public or commercial pool will materially affect its success. To obtain the most patronage, the pool should be easily accessible by foot, public transportation and automobile. Parking space for autos must also be considered. Existing parks are generally fairly well located to meet these requirements. By using property already publicly owned, the cash outlay for the pool will be reduced.

An adequate water supply and suitable drainage must also be considered in selecting both the site and the location of the pool on the site.

Where property must be purchased for the pool, it will generally be found that the most desirable location from the standpoint of accessibility and facilities is more expensive than some outlying location. It then becomes necessary to balance the increased cost of the best location against the increased patronage that may be expected.

In municipal developments, the public will generally be served better by constructing two or more pools of reasonable size in different parts of the city than by constructing one extremely large pool. The initial cost and operating costs will be somewhat increased so that the extra convenience and increased use must be balanced against the increased cost.

The advantage of several small pools over one large pool applies even more to wading pools than to swimming pools. Most of the children using wading pools are attended by their mothers, so that locations within walking distance of the homes are desirable.

After the selection of the site comes the exact location of the pool on the property. In a complete park or recreational development, the location of the pool will be made with reference to the other facilities. Wherever possible, the pool should be located so that it is protected from the prevailing winds by the bathhouse, a wall, a hedge or some other windbreak. A very satisfactory enclosure is made by forming a ridge with the material excavated from the pool and planting a hedge on top of it. In some cases it will be advisable to locate the pool so as to provide some shade although, in general, sunshine is highly desirable.

Trees will provide a picturesque setting but are generally a nuisance. Falling leaves make it difficult to keep the pool clean and the roots may clog the drainage tile and push sidewalks out of position.

It is preferable to have the bathhouse along the shallow part of the pool so that poor swimmers will not dash from the bathhouse into the deep water. If the filtering equipment is located in the bathhouse, there may be a slight saving in cost by placing it near the deep water, but the safety feature should not be sacrificed for this small saving.

At country clubs the pool should be so located that the noise from the bathers will not disturb the golfers, particularly those on the putting green. It should be easily accessible from the regular dressing rooms. If the pool is not enclosed, it should be located so that people in street shoes will not ordinarily use its walks.

SIZE

Size of the proposed pool is a very important question which should be determined only after careful consideration of several important factors. The pool should have sufficient area to accommodate the largest number of people who may be expected frequently during the season, but it should not be designed for the maximum number who may be expected only a few times a year. It must not be so large as to be wasteful of water or space under ordinary conditions, or to appear poorly patronized. It is better to have the pool too crowded a few times each season than to have it so large that operating costs are excessive. The available building site and the amount of money which can be raised for the purpose will also have an important bearing on the size of the pool.

Where studies show that attendance will justify a large area pool, there is a growing tendency to construct separate pools for diving and swimming. This eliminates much of the danger of accidents between a diver and someone in the water. It also makes the pools easier to police.

Attendance

In determining the size of a pool, the first thing to be done is to estimate the attendance. This is not so difficult for a country club or other private or semi-private pool, but it is quite difficult to make an accurate estimate for a public pool. There are no fixed rules for estimating attendance at a public pool. A careful study by an experienced pool designer is necessary. Some of the points to be considered are: climatic conditions, local habits and customs, accessibility, competition from other pools and admission fees. Experience of pools in similar situations is one of the best guides. The operation of the pool will also have a very great effect upon the attendance.

A study by Iowa State College has shown that the size of the city has considerable influence on the proportion of total population which will attend the pool. The smaller the community the larger the proportion which will use the pool. The study indicated that for cities under 30,000, maximum daily attendance will be between 5 and 10 per cent of the population. Another rule is to consider the average daily attendance as 2 to 3 per cent of the population. Maximum daily attendance will generally be 2 to 6 times average daily attendance. Maximum attendance at any one time seems to be about one-third the daily attendance. Combining these values shows that the attendance at any one time on the maximum days will be about the same as the average daily attendance. Designing for this attendance should give a pool of sufficient size for maximum days and of very generous size for average days. These methods of computing attendance are for public outdoor pools and should be considered only as rough guides where better information is not available.

Area

The most common methods of determining the capacity of pools are those of the Joint Committee*, which base the capacity upon both the surface area and upon the water volume and treatment.

The capacity based on surface area considers that

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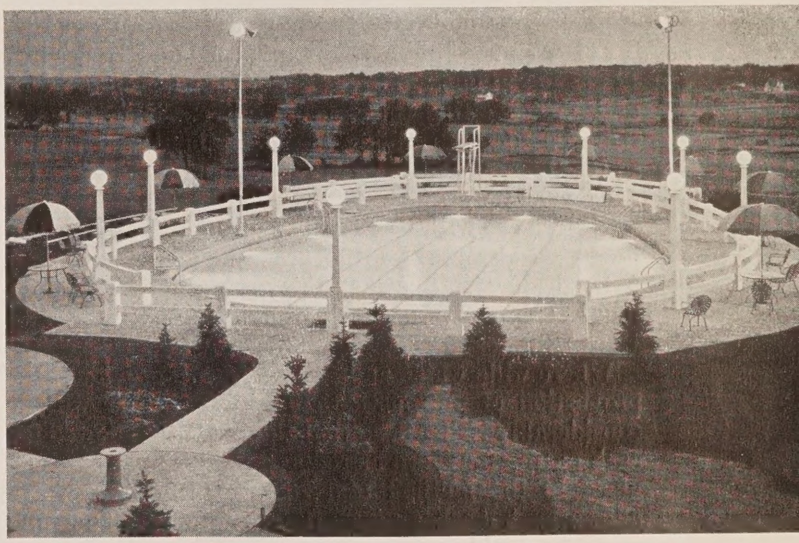
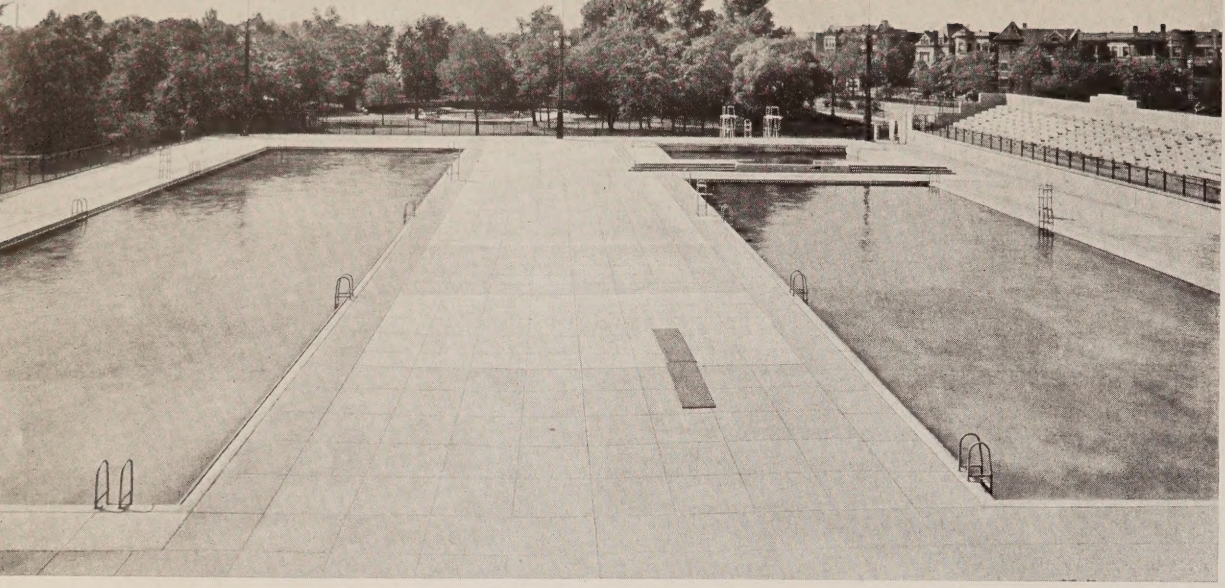
*Report of Joint Committee on Bathing Places of the American Public Health Association and the Conference of State Sanitary Engineers.



Dusk lends added enchantment to the pool at the Edgewood Valley Country Club, LaGrange, Illinois. The precast concrete fence separates bathers and spectators. Straight wall sections provide for turning at ends of racing lanes. Wesley Bintz, designer.

The T-shape is used to separate the divers and bathers at Riis Park pool of the Chicago Park District. Note the large proportion of bathers using the shallow water.



The multiple-unit pool in Washington Park, designed and built by the Chicago Park District. General pool, left; competition pool, right; diving pool, right rear; and wading pool at the rear outside the pool enclosure. Concrete grandstand for spectators is easily maintained.

each swimmer and bather requires a certain area in which to move. The area where water is more than 5 ft. deep is considered as swimming area and that of lesser depth as bathing area. Considering that only part of those in attendance will actually be in the water, it has been decided that 27 sq.ft. of deep water or 10 sq.ft. of shallow water is required for each person in attendance at one time. Water less than 3 ft. deep cannot be used effectively by the average person.

It is assumed that each diving board may be used by 12 persons at one time, part of these being in the water and part awaiting their turn to dive. Since the area required for each diving board is about 300 to 400 sq.ft., the area for each diver is about the same as for each swimmer.

Experience with large outdoor pools has shown that about 75 per cent of the area should be less than 5 ft. deep. For pools of this proportion the above requirements give an average over the entire area of 12 sq.ft. for each person in attendance.

Where wide walks and play areas are provided, the proportion of patrons actually in the water will be considerably reduced, so that the pool area allowed for each patron may also be reduced. This factor is recognized in the method of computing capacity which allows each bather 20 sq.ft. of combined pool and walk area.

Volume

The bathing capacity of the pool is limited by the water content and the amount of clean water added, as well as by the surface area. Clean water includes both fresh water and treated recirculated water.

The Joint Committee and many states specify that the total number of bathers using a pool during any period shall not exceed 20 persons for each 1,000 gallons of clean water added during that period. Where the addition of disinfectant is not continuous during the bathing period, the total number of persons using the pool between disinfections should not exceed 7 for each 1,000 gallons of water in the pool.

Under these Joint Committee regulations, in pools of ordinary proportions and with a complete water turnover period of 8 to 12 hours the bathing load generally will be limited by the surface area rather than the water supply. However, the water supply or circulation should always be checked, since it may be the controlling factor, particularly in pools having a continuous series of classes and in those having a very large proportion of shallow water.

With the old type "fill-and-draw" pool (see page 17) the water volume and disinfection becomes very important even for the small private pool, which is about the only type now being built with this system. Applying these requirements to a pool of 8,000-gallon capacity, $\frac{8,000}{1,000} \times 20$ or 160 persons could use the pool before changing the water, but the pool should be disinfected after use by $\frac{8,000}{1,000} \times 7$ or 56 bathers and again for every 56 additional bathers.

Another method of determining bathing capacity for recirculating pools is described in *Minimum Sanitary Requirements for Swimming Pools and Bathing Places*, issued by the Department of Public Health, State of Illinois. Under these regulations the bathing load is determined from the formula:

$$BL = \frac{C \times M}{T^3}$$

in which BL is the maximum number of bathers daily, C is water content of pool in gallons, T is time in hours required to recirculate the entire content of the pool, and M is an arbitrary multiple depending upon many factors including: indoor or outdoor pool; width and drainage of walks; use of suits and caps; use of private suits or suits laundered after each use; enforcement of cleansing bath before using the pool; efficiency of recirculating system; and general arrangement of bathhouse and pool surroundings. This coefficient usually varies between 2 and 6. With a reasonably well-designed and operated outdoor pool, the coefficient will be about 2 when there is no suit control, and 3 when only regulation suits laundered after each use are worn.

SHAPE

Pools of rectangular shape are the most common and generally the most satisfactory, but there are some advantages to circular, oval, and irregular-shaped pools.

Rectangular pools are simple to design and construct. They are also superior to other shapes for the conduct of swimming meets since they provide uniform racing lanes with good ends for turning. If meets are to be held in oval pools, temporary bulkheads, for which provision should be made in the original design, must be erected for starting and turning.

Round or oval shapes have been used for large public pools. The advantages claimed are: by providing shallow water around the entire perimeter of the pool, the danger of nonswimmers falling into deep water is eliminated; the volume of water is less than for rectangular pools of the same area, thus costing less to operate; and the construction cost is less. The disadvantages are: the difficulty of holding competition; the additional cost of the diving platform and waste of the expensive deep area of the pool used by the platform; the greater volume of water and increased cost of construction and operation if proportions of deep and shallow areas are the same.

Recently several pools have been constructed of special shapes intended to improve operation. Some of these are of L or T shape with the diving in the stem of the T or one leg of the L and swimming in the remainder of the pool. Oval pools have also been built with one side modified to provide for diving, rather than having the diving platform in the center.

A few irregular-shaped pools have been built to fit the contour of the ground or for architectural reasons. In some pools the simplicity and stiffness of completely rectangular pools has been modified by curves at one or both ends.

Swimming meets of some kind will be held in practically all but private pools, even though they are not originally contemplated. Therefore, such meets should be given some consideration in the design.

The national and international organizations controlling swimming meets and records are quite liberal in the specifications for the length and width of pools. Three sets of records are recognized. One set is for pools 60 ft. to 75 ft. in length; another for pools 75 ft. to 150 ft.; and a third for pools more than 150 ft. in length.

There are certain convenient lengths which provide an even number of laps for recognized contests. Some of these convenient lengths are 60 ft., 75 ft., 25 meters (about 82.5 ft.), 100 ft., 150 ft., and 165 ft. (55 yd. or slightly more than 50 meters). The actual length of the completed pool must be the full nominal length, not even a fraction of an inch less, or records made therein will not be recognized. It is wise to build the pool 1 or 2 in. longer than the nominal length.

The width should provide at least four lanes. In the larger pools the width may be made the same as given for standard lengths and races held across the pool. The minimum width of racing lanes is 6 ft. Greater widths of lanes are desirable.

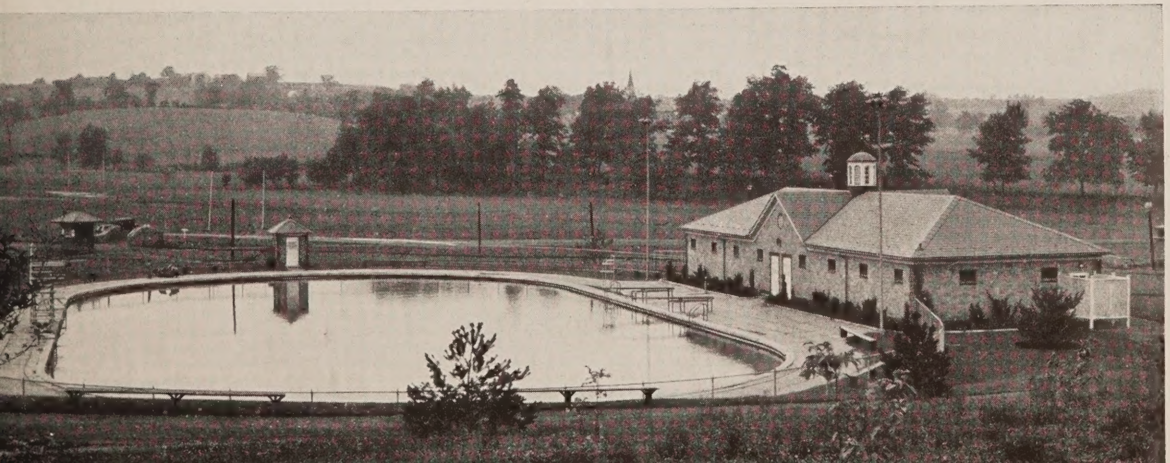
In marking the bottom of the pool it should be remembered that the competitor swims over the line and not between lines. For important meets it is desirable to have surface lane markers as well as lines on the bottom. Attachments for such markers should be cast in the walls. The width of exterior lanes may be the same as interior lanes, but this must be the clear width without any obstructions such as ladders.

If a pool is to be built primarily for competitive meets, more attention should be given to the requirements and recommendations of the controlling athletic organizations than is necessary for the average pool. The suggestions given here are for pools in which meets will be held only occasionally.

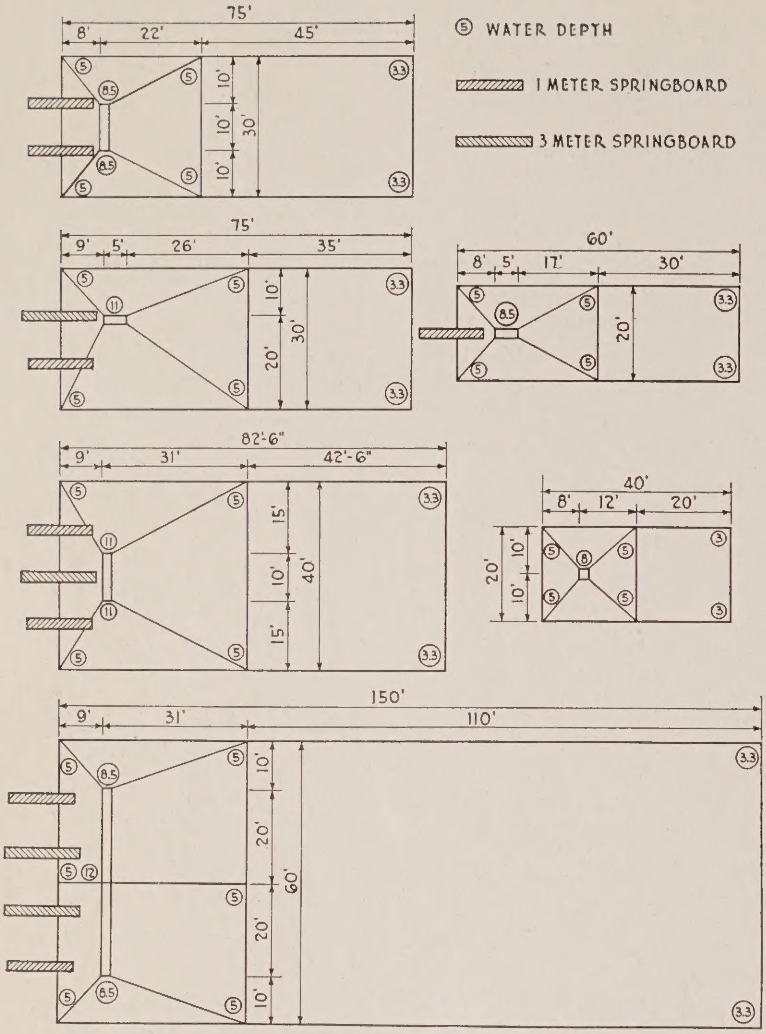
DEPTHS

As with the length and width of pools, the athletic authorities have few fixed limits on the depth. The water must be at least 3 ft. deep and the starting platform from 18 in. to 30 in. above the water. To assure 3 ft. of water, the overflow should be a few inches more than 3 ft. above the pool bottom.

There are no strict rules for depth of water under diving boards, nor is there unanimity of opinion on this point. However, the best opinions seem to be that absolute minimum depths should be 8 ft. for the 1-meter board and 9½ ft. for the 3-meter board. Greater depths are desirable, particularly under the 3-meter board and some authorities give this minimum depth as 11 or 12 ft. Most common depths are 10 or 11 ft.



The recreation center at Nazareth, Pennsylvania, Borough Park includes this swimming pool with curved ends and a circular wading pool at the right of the bathhouse, of hollow concrete units. Edwin H. Jones, architect.



Typical layouts.

Location of the deep water and slope of the floor are fully as important as depth. Minimum allowable depth of deep water should extend outward about 4 ft. from the end of the board. The length of the board, the method of supporting it, and the design of the overflow will all affect the distance from the end of the board to the face of the pool wall, which may be between 4 and 9 ft. but will ordinarily be 6 or 7 ft.

The bottom of the pool may slope up quite rapidly behind this point and at the sides, but in front of the board the slope should be more gradual. The bottom may slope up to a water depth of 5 ft. at a point about 30 ft. from the end wall for a 1-meter board and 40 ft. for a 3-meter board.

These depths and areas of deep water should be the absolute minimum and greater depths and areas are preferred.

Where separate pools are provided for swimming and diving, the depth of the swimming pool may vary from 3 ft. 3 in. to 5 ft., and the depth of the diving pool will be governed by the height of the diving boards or platforms.

Within the wading depth of water, up to about 5 ft., there should be no steps or steep slopes. The Joint Committee gives the maximum slope as 1 to 15, but considerably steeper slopes have been used satisfactorily in small pools. A definite slope for all parts of the floor will aid in keeping it clean.

The longitudinal section of most pools for swimming and diving is in the form of a spoon. This provides the proper depths with the greatest economy. In the past it has been customary to make the cross-section practically level except in the larger pools. Recently the floor at the deep end has been sloped from the sides as well as the ends, thus forming a hopper bottom which saves excavation and reduces the depth of side walls. It also aids in keeping the floor of the pool clean where the water for recirculation is withdrawn from the bottom of the deep end. The extra difficulty of constructing this type of bottom is slight.

A recent development of the hopper bottom places the opening for the main drain parallel to the springboard rather than at right angles to it. For pools having only one board, the drain is placed in line with it. If there is a high-board and one or two low-boards, the drain is placed in line with the high-board and the floor sloped up to the sides so that there will be sufficient depth under the low-boards.

DESIGN

Every pool should be designed by a competent engineer or architect to meet specific local conditions.

Outdoor pools are usually built entirely in the ground, although a few have been built above the ground with the pool wall serving also as one of the walls for the bathhouse. This type has some advantages where the ground water is close to the surface.

Indoor pools may be built in the ground, the same as outdoor pools, or in one of the upper stories and thus be supported by the building frame. In the latter case, special precautions should be taken to prevent uneven settlement of foundations and damage to lower floors caused by possible leakage or condensation.

Forces

Pools built in the ground should be designed to withstand the water pressure from within and to resist the pressure of the earth when the pool is empty. In general, it is inadvisable to consider the lateral earth pressure as aiding in resisting the internal water pressure. The type of soil and other local conditions will influence the selection of earth pressure to be used in the design. In some cases it may be necessary to consider external water pressure.

To prevent the possibility of cracks forming as a result of temperature changes and shrinkage, it is necessary to provide sufficient reinforcement and correctly designed expansion joints in the walls and floor. Adequate curing of high quality concrete will reduce the possibility of cracks.

Subsurface Drains

It is economically impractical to design the floor to resist much hydrostatic head or to resist the heaving action of frozen wet subsoil. Therefore it is essential that the pool have adequate subsurface drainage. The minimum drainage system that should be considered is a line of tile around the outside of all footings and a line under the deepest portion of the pool. For large pools there should be additional lines of tile under the pool. Where the subsoil drains very slowly, it will be advisable to place the floor on a bed of sand or cinders 6 to 8 in. thick which has been thoroughly wetted, tamped and rolled. If cinders are used, all metal pipe passing through them should be encased in concrete to prevent corrosion.

Structural Types

The most common type of pool design consists of cantilever walls with separate floor. This type is simple to design and construct. A modification is the cantilever wall with the base cast integrally with the floor, which gives a small saving in materials but is slightly more difficult to design and construct.

Another type might be called beam-and-slab construction, in which the top of the wall and the sidewalk are designed as a beam and the wall as a slab spanning between the beam at the top and the footing. The horizontal thrust on the beam is resisted by wall buttresses built between the beam and the footing.

Small pools with the floor cast integrally with the walls may be economically designed as open top boxes, part of the stress in the walls being carried vertically as a cantilever and part horizontally as a beam supported at the ends.

The use of large slabs of cast stone as the structural wall as well as a finish has developed what might be called the structural frame type of pool. In this type the precast slabs span between columns or buttresses which transfer the horizontal forces to the footings. This construction is particularly fitted to pools in which colored walls are desired.

Some pools have been built of shotcrete, which is a mixture of portland cement, sand, and water applied by compressed air. This method eliminates the use of forms on most of the work. Its use is limited to soils which can be shaped to the desired contour and which will retain this shape until the shotcrete is placed. Under these conditions the construction is quite satisfactory and economical.

Minimum Sections and Reinforcement

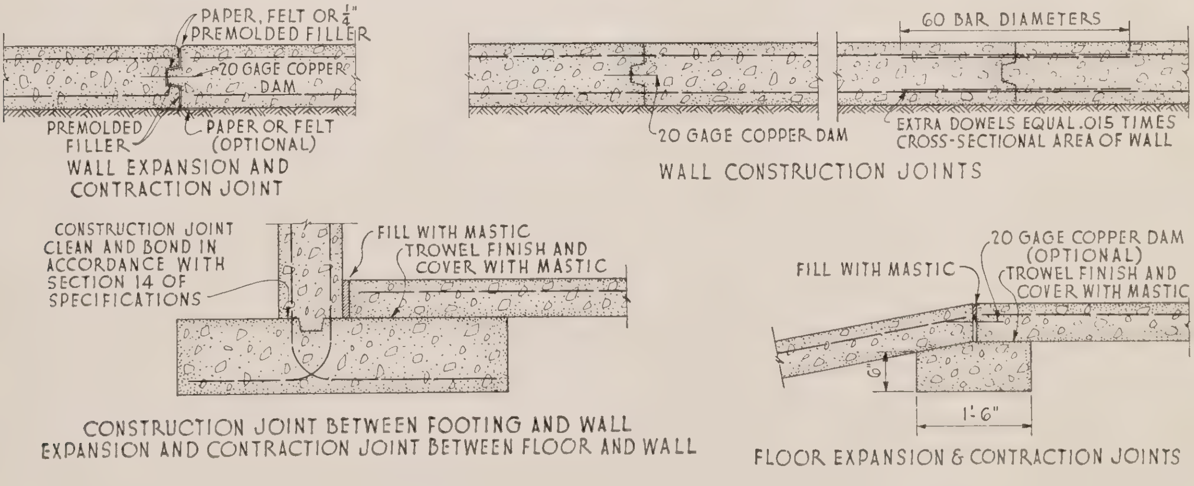
The thickness of walls and floors and the amount of steel will often be governed not by strength requirements but by the minimum space needed for placing concrete and by experience. In general, walls of the cantilever type are not less than 10 in. thick, while those of the beam-and-slab type are not less than 6 in. The thickness of precast slabs is about 4 in. and floors are usually not less than 6 in. thick.

The minimum amount of horizontal steel in walls will depend upon many factors, including expected temperature range, distance between joints, and quality of concrete and methods of placing and curing. The least amount of horizontal steel in walls should be 0.0025 times the cross-sectional area of the wall. With good subsoil and drainage, about one-half this amount has given satisfactory results in floors.

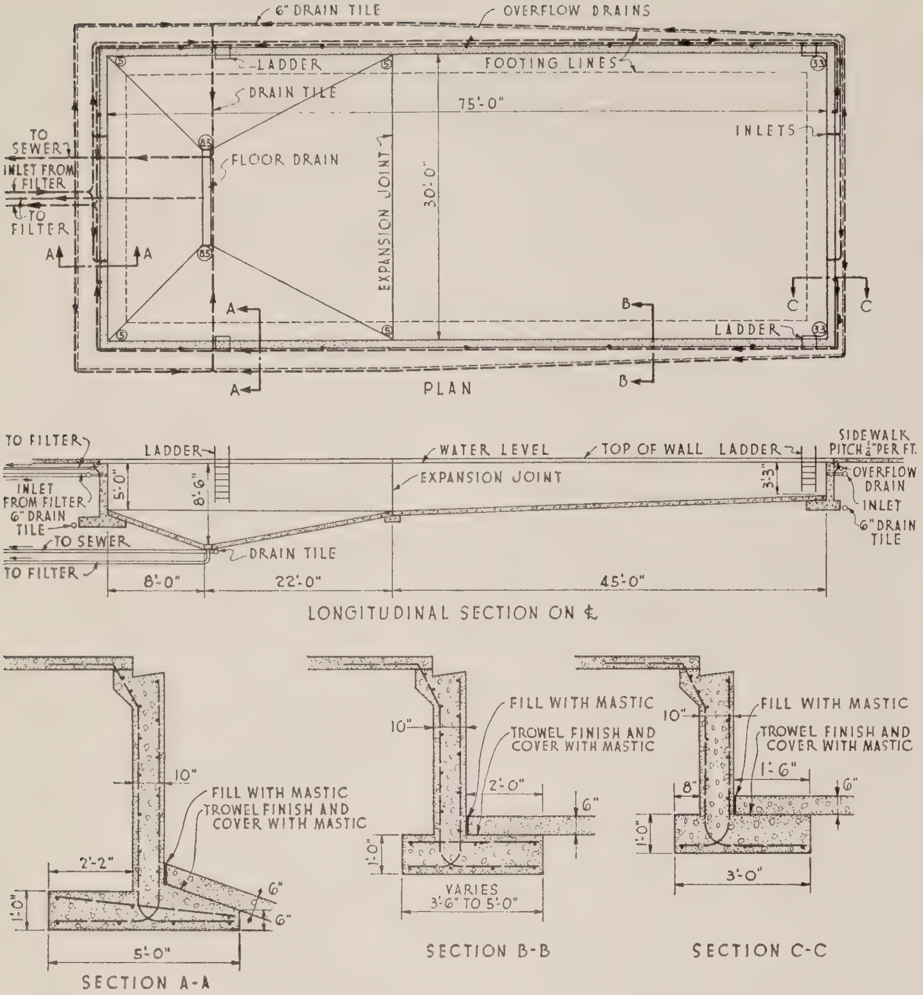
Joints

Practically all pools contain either construction joints or expansion joints or both. The proper location, design and construction of these joints are very important in obtaining a watertight pool. Construction joints are intended to be rigid and not allow movement, while expansion or contraction joints are intended to allow for the movement caused by changes in temperature and moisture content.

Construction joints should be avoided as much as


PAPER, FELT OR 1/4" PREMOLDED FILLER
20 GAGE COPPER DAM
PREMOLDED FILLER
PAPER OR FELT (OPTIONAL)
WALL EXPANSION AND CONTRACTION JOINT
60 BAR DIAMETERS
20 GAGE COPPER DAM
EXTRA DOWELS EQUAL .015 TIMES CROSS-SECTIONAL AREA OF WALL
WALL CONSTRUCTION JOINTS
CONSTRUCTION JOINT CLEAN AND BOND IN ACCORDANCE WITH SECTION 14 OF SPECIFICATIONS
FILL WITH MASTIC
TROWEL FINISH AND COVER WITH MASTIC
CONSTRUCTION JOINT BETWEEN FOOTING AND WALL
EXPANSION AND CONTRACTION JOINT BETWEEN FLOOR AND WALL
20 GAGE COPPER DAM (OPTIONAL)
FILL WITH MASTIC
TROWEL FINISH AND COVER WITH MASTIC
6"
1'-6"
FLOOR EXPANSION & CONTRACTION JOINTS

Typical expansion and construction joints.



Suggested design for 30 x 75-ft. swimming pool.

possible by planning the work so that a complete section between expansion joints may be placed in one continuous operation. However, it will generally be necessary to make a construction joint at the base of the walls. Such horizontal joints can be made satisfactorily by simply bonding the new concrete to the hardened concrete as described in Section 14 of the specifications. At such joints it is good practice to key the two sections by making a longitudinal slot in the center of the first section before concrete hardens.

Vertical construction joints in walls should be keyed together and a water stop used, or extra dowel bars should be used equivalent in area to 0.015 times the cross-sectional area of the wall and extending 30 bar diameters on each side of the joint.

Construction joints are seldom necessary in floors, but if required should be made the same as suggested for vertical construction joints in walls, or an expansion joint should be provided. Screeds must be removed as soon as possible and the space filled with concrete worked into the adjacent portion of the slab.

The expansion joints in walls should be keyed and made watertight with water stops. Reinforcement should not extend across any expansion joint.

Expansion joints in floors should be made over a beam or footing or some special type of joint used which will keep the adjacent slabs in line as well as being watertight. The most common type of joint is made with a metal water stop and mastic fill. Where the ends of the slab rest on beams or footings, the water stop is frequently omitted and dependence for watertightness placed entirely on the filling and mastic between the slab and the footing or beam. The use of asbestos fibered mastic or multiple layers of open mesh burlap mopped with mastic will permit differential movement and assure the mastic remaining in place. Strips of soft clear grain wood may be used as filler between slabs.

Offsetting the expansion joint in the floor about 1 ft. from wall joint will aid in making tight joints.

The proper location and spacing of expansion joints must be determined for each job, and since there are no fixed rules for this determination, some general comments will be helpful. They should be placed where there will be the greatest tendency to crack, such as at changes in section or direction of members. For pools of regular shape, such points will be at the junction of floor and walls and where there is a sharp change in grade of the floor. The distance between joints should ordinarily not exceed 60 ft. However, a number of successful small and medium-size pools have been built without expansion joints.

Openings

There is always a tendency to crack where there is a reduction in section such as caused by holes for lights, pipes and other fixtures. For this reason extra reinforcement should be added at these points to make up for the concrete removed. The extra reinforcement should be about 0.015 times the cross-sectional area of the concrete removed and bars should extend about 30 diameters beyond edges of the opening.

Overflows

Overflows were formerly called scum gutters and considered more or less as sewers, the water and other material which entered them being wasted directly to the sewer. This idea has been materially changed since it has been found that body wastes are distributed throughout the pool and that in a well-operated pool there is no collection of scum on the surface. There is a growing tendency to recirculate overflow water.

Overflow gutters are of many shapes, but they may be broadly classified as the open or roll-over type

(A, B, C and D) and the deep or recessed type (E, F and G). The former type is increasing in popularity.

The entire overflow should be clearly visible and easily cleaned. Needless to say, it should be easy to construct. The overflow and walk should be so arranged that water from the walk will not drain into the pool. The most definite way of protecting the pool from drainage is the use of curbs between the walk and the pool. With the open type overflow, any drainage from the walk will be intercepted before reaching the pool proper. If the walk is pitched to drain away from the pool as it should be in all outdoor pools, the slight amount of water which would drain into the overflow would not be serious, regardless of whether the water is recirculated or drains to the sewer.

The overflows should have outlets at fairly close intervals and the bottom of the overflow should be definitely pitched, about ¼ in. per ft., to drain to these outlets. The maximum spacing of outlets recommended by different authorities varies from 10 to 20 ft.

The overflow may be discontinued for about 6 in. each side of expansion joints in the wall so that there will not be a joint through the overflow.

Great care must be used in construction to see that the lip of the overflow is absolutely level around the entire pool. A surveyor's level should be used, as an ordinary hand level is not sufficiently accurate.

Service Tunnels

A number of pools have been built in which a service tunnel extends along one or all of the sides. The service tunnel allows quick and easy access to the piping and underwater lighting where such is used. Underwater observation booths, of assistance to coaches, can be built as a part of these tunnels.

Walks

The walk areas around the pool are an important part of the development but are frequently given little thought. The surface should be non-absorbent, non-slip to bare feet, easy to clean, and sloped about ¼ in. per ft. to frequent drains so that water will drain off quickly. In indoor pools where the only water on the walks is that from the pool, the drainage may be into the overflow. In outdoor pools, the drainage should always be away from the pool, except that where the overflow is not recirculated the walks are sometimes allowed to drain into the overflow gutters. There should be a curb at the outside edge of the walk to keep out dirt and litter.

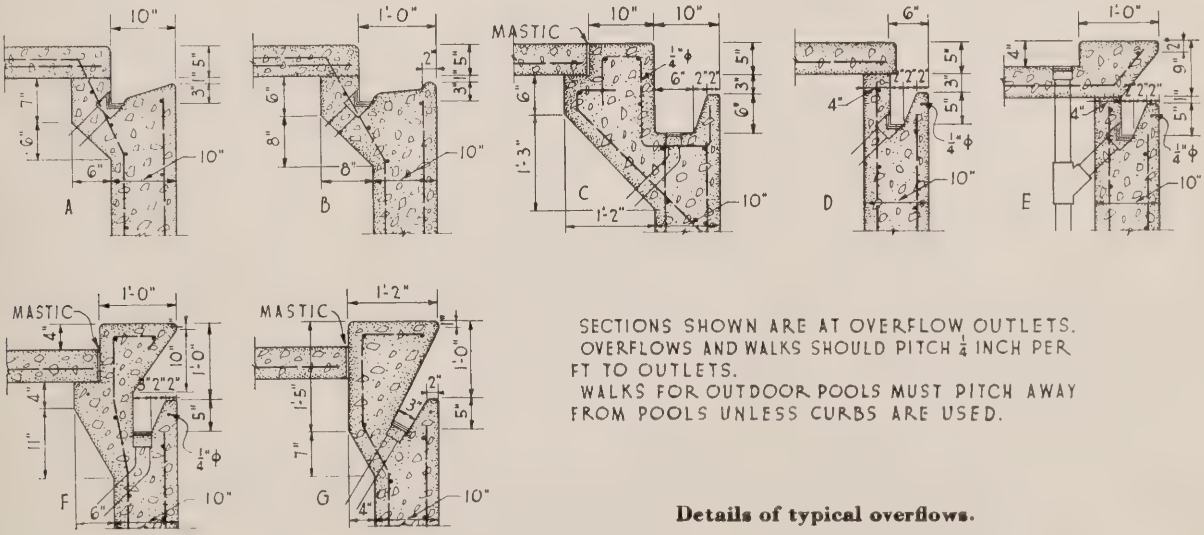
The entire pool should be surrounded by walks at least 4 ft. wide for interior pools and private outdoor pools and 12 ft. wide for other outdoor pools. The minimum clear width of walks should be maintained around diving and other recreational equipment. The width of walks should be increased for the larger size pools. From an operating standpoint, the width will never be too great.

Providing ample areas around the pool will tend to reduce the number of persons in the water, which will be particularly advantageous when attendance is large.

Although the surface must be non-slip, it should not be rough enough to hurt the feet. Satisfactory results may be obtained by using a brush finish, lift finish, or special abrasive aggregates. The brush finish is made by lightly brushing the surface with a fine hair brush after the final troweling. The lift finish is obtained after the final troweling by lifting the surface with some implement such as burlap or carpet fastened to a float. Special abrasive aggregates may be incorporated into the surface by evenly dusting about ¼ to ½ lb. per sq. ft. on the surface before troweling.

Terrazzo containing an abrasive aggregate is decorative and effective for walks and other paved areas.

Concrete that has been allowed to harden before being given a non-slip surface may be treated with muriatic acid. A 5 to 10 per cent solution is generally used. Drenching the surface with water before the acid is applied will keep the acid from soaking into the concrete and give a more uniform distribution. A liberal amount of acid solution should be scrubbed on with a stiff fiber brush and the surface then rinsed with clear water. More than one application may be necessary.



SECTIONS SHOWN ARE AT OVERFLOW OUTLETS.
OVERFLOWS AND WALKS SHOULD PITCH ¼ INCH PER FT TO OUTLETS.
WALKS FOR OUTDOOR POOLS MUST PITCH AWAY FROM POOLS UNLESS CURBS ARE USED.

Details of typical overflows.

The Oak Park, Illinois, Country Club pool includes many modern features. The off-center hopper bottom economically provides adequate depth for the 3-meter board. Inserts in the walk close to the pool make the erection of a guard chain a simple matter. The hedge around the walk will keep spectators out of the pool area, stop leaves and refuse from blowing into the pool, and will eventually serve as a windbreak for the bathers. Underwater and overhead lights not shown in the picture make night bathing safe and attractive. The recessed ladder is another safety feature. The pattern in the concrete walk is emphasized by brushing adjacent sections in different directions. Mayo and Mayo, architects.

Keeping walks clean will reduce slipping. Simply rinsing with water may not remove surface films which sometimes cause slipperiness. Such a condition may be eliminated by periodic scrubbing with abrasive powder or a detergent followed by thorough rinsing. Ordinary soap powders should not be used.

To encourage frequent and thorough cleaning, there must be a sufficient number of hose connections so that all the walks can be reached with short lengths of hose. For adequate water volume and pressure, the piping and hose should be not less than 1 in.

Quality Concrete

A satisfactory swimming pool requires good quality concrete work. This depends upon the quality of materials, ratio of water to cement, proportions of materials, placing, and curing.

Materials meeting requirements given in specifications on page 26 will give satisfactory results.

The watertightness, strength, durability and other desirable properties are dependent upon the water-cement ratio, which is the amount of water used with each sack of cement. For swimming pools, it is recommended that the concrete contain not more than 6 gal. of water—including that carried by the aggregate—to each sack of portland cement.

The concrete must be of such a plastic consistency that it will work into all parts of the forms without leaving voids or honeycombing or allowing free water to accumulate on top of the concrete. With a given water-cement ratio, the consistency is controlled by the proportions of cement, fine aggregate and coarse aggregate. The proportions will depend upon the maximum size and grading of aggregates. Well-graded aggregates will give the best and most economical job. The exact proportions will depend upon the aggregates used and the method of placing and can be determined best by making trial batches. With average aggregates and hand placing, proportions will be approximately 1 part portland cement, 2½ parts fine aggregate, and 3½ parts coarse aggregate measured by loose volumes. All materials should be measured accurately.*

Concrete may be satisfactorily placed and compacted by hand spading, rodding and tamping or by mechanical vibration.* The latter method permits satisfactory placing with stiffer mixes than can be placed by hand, which reduces the shrinkage and gives a more economical mix.

Curing is one of the most important yet most neglected factors in production of durable concrete construction. Curing increases the watertightness and strength of concrete and reduces shrinkage. Adequate curing is the most economical factor in improving the quality of concrete. Exposed surfaces should be kept continuously moist for a period of at least 7 days.

SPECIAL FEATURES

Finish

Swimming pools may be finished in the natural concrete color or any other desired color by one of several methods. Regardless of the color desired, the surface should be smooth and hard. Light colors are preferable to dark colors.

If the concrete is to be left exposed, whether colored or not, the forms must be carefully made to give reasonably smooth surfaces. Immediately after the forms are removed, all projections on the exposed surfaces should be removed, any irregularities filled, the surface rubbed with carborundum and thoroughly rinsed.* If the forms are lined with large sheets of a smooth material, such as plywood or composition board, a smooth surface will be obtained with a minimum amount of work.

The floor of the pool should be finished true to grade, and where the water is less than 5 ft. deep should have a float finish or non-slip surface as dis-

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*Additional information on quality concrete and vibration is contained in *Design and Control of Concrete Mixtures; Design of Concrete Mixes; Vibration; Finishing Architectural Concrete.*

cussed for walks. In deep water, a smooth troweled finish will aid in making the bottom self-cleaning.

Colored pools may be obtained by use of paint, plaster, integral facing, terrazzo, cast stone or tile.

For the floor of the pool, the most economical and satisfactory results will be obtained by using the "dusted-on" finish. The dusted-on mixture should be composed of 1 part of portland cement to 1½ parts of dry sand and the required amount of pigment. After the floor has been screeded, this mixture should be uniformly spread at the rate of not less than 125 lb. per 100 sq. ft. of floor area and floated into the slab. White portland cement and silica sand applied in this manner are advantageous for the floor of the pool even if the walls of the pool are left in their natural color.

Painting has been the most common way of obtaining colored pools, but before deciding to paint a swimming pool it must be realized that once the pool is painted there will be a continuous maintenance cost. Paint seldom can be expected to last more than 2 or 3 years and in most cases pools are repainted every year. However, periodic painting adds materially to the attractiveness of the pool by keeping it looking fresh and clean.

There are examples of both successful and unsuccessful use of practically all paints. The principal reason for poor results is improper preparation of the surface and improper application of the paint. The manufacturer's recommendations should be carefully followed in all details.

Regardless of the type of paint used, the surface of the pool must be clean and free from old paint which may scale. When portland cement paint is used, the surface must be damp when the paint is applied and must be kept damp for at least 2 days after painting so that the cement can hydrate. With other types of paint, the surface must be dry when the paint is applied and the paint must be allowed to completely harden before the pool is filled.

If colored cement plaster or concrete is used, only high-grade mineral colors should be considered*. Cheap colors will fade, and even with high-grade pigments it is difficult to obtain permanent color of certain shades. To obtain the desired color it may be necessary to use white portland cement and white or specially selected colored aggregate as well as mineral colors. It will often be advantageous to use factory-mixed cement and pigments, thus eliminating this work on the job and obtaining more uniform results.

Much of the trouble with colored concrete has been that the desired color is obtained with the cement paste which covers the surface of the new work, but as soon as this wears off slightly the aggregate is exposed, thus changing the color effect considerably. To determine the final effect, a sample of the surface finish to be used may be rubbed or ground slightly to expose the aggregate.

If the walls are to be plastered, they should have a rough surface so that there will be a mechanical bond with the plaster. A satisfactory surface may be obtained by using rough form lumber, lining the forms with coarse burlap, or roughening with a heavy wire brush or scoring tool if the forms are removed early, generally within 24 hours. Oil or soap should not be used on the forms. The walls should be clean and damp when each coat of plaster is applied. The first coat should be dashed on the wall with a stiff brush, using a sharp whipping motion. Care must be exercised to insure a good bond and to eliminate the possibility of water getting between the concrete and the plaster. Other requirements are the same as for plastering or stuccoing on any concrete wall.* Adequate curing is very important.

Cast stone—precast concrete slabs—may be used to form the entire thickness of the wall or to act as forming and facing for a cast-in-place concrete wall. In the former construction, a reinforced concrete frame is cast behind the precast slabs. In the latter construction, the precast slabs are used as the front form and facing of an ordinary concrete wall.

Colored tile, vitreous or glazed brick, or cast stone make attractive linings for swimming pools. The wall surface should be rough to aid in obtaining a good bond for the mortar in which these units are set. Care must be taken, particularly in outdoor pools, to prevent water from getting between the concrete and the lining.

Winter Protection

The best protection of outdoor swimming pools during the winter is a moot question, partly because winter damage to properly designed and constructed pools is so rare that no definite conclusions can be drawn as to the effectiveness of the various methods.

In the past most pools were drained. A few of these had the bottom covered with straw, while others were completely covered with a roof. In some cases water is left in the pool throughout the winter. Of course, in all cases, pipes should be drained and equipment properly protected.

The children's pool at Westwood Common is one of many scattered over Cincinnati. Each pool has showers and a comfort station. The wide distribution of these small pools provides healthful recreation within walking distance for nearly all children.

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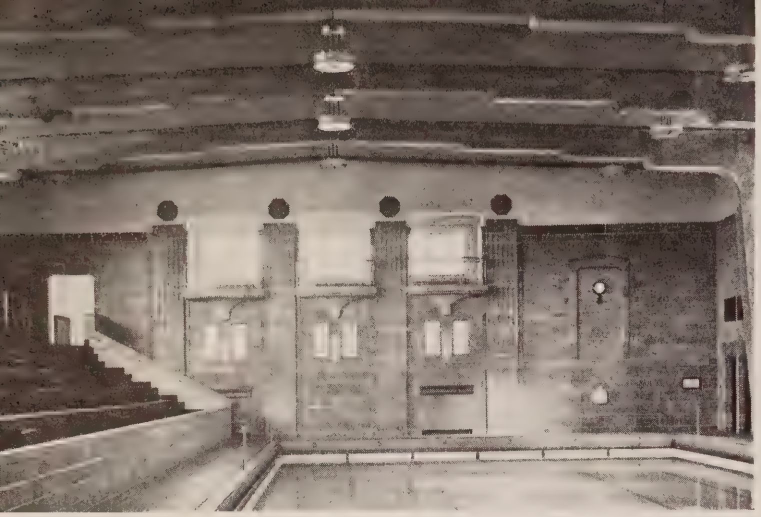
*Additional information is contained in *Mineral Pigments for Use in Coloring Portland Cement Concrete* and *Plasterer's Manual.*



Walls of cinder concrete masonry and ceiling areas broken by reinforced concrete rigid frames reduce reverberation in the pool of the Iowa State Teachers College, Cedar Falls, Iowa. Concrete bleachers, separated from the pool, are easily kept clean. Keffer and Jones, architects.

The graceful diving stand of reinforced concrete adds to the beauty of the pool setting at the Rockford, Illinois, Country Club. Mogens Ipsen, engineer.

While the force exerted by the freezing of water in a closed receptacle is tremendous, the force exerted by the ice in a swimming pool does not seem to be dangerous. Since the ice forms gradually and is free to expand in a vertical direction, it will buckle in the center of the pool as soon as horizontal pressure occurs due to freezing of a thin sheet. Owing to this progressive action and the fact that the volume of ice decreases as the temperature falls below the freezing point, the pressure developed on the walls is not dangerous.

Another factor which reduces the effect of the lateral pressure from the ice is that the surrounding ground freezes at the same time, and consequently assists the walls in resisting any outward lateral force.

Having the pool filled with water the year around will reduce the volume change in the concrete by practically eliminating change in moisture content and reducing the maximum temperature variation to about 50 degrees. Not only is the maximum temperature variation reduced, but the number of cycles of high and low temperatures is very greatly reduced.

The most important objection to leaving water in the pool during the winter is the possibility that the wall surface at the water line may be damaged by alternate freezing and thawing.

Where water is left in the pool during the winter, all the pipes should be drained, and special equipment, such as lights, should be protected in accordance with the manufacturer's recommendations. The overflow drain should be left open so that no ice will form in the confined space of the overflow. Ordinarily, it is best to have the level of the water several inches below the overflow. However, if it is desired to flood the pool clear to the top, there should be no objection as long as the overflow gutter is very definitely below the surface so that any pressure exerted by ice in the overflow will be resisted by the ice from the outside.

If the pool is drained for the winter, it is very important that there be adequate subsurface drainage to prevent heaving of the floor slab caused by freezing.

An unguarded swimming pool is a distinct accident hazard to both people and animals whether the pool be empty or full. This is particularly true in the winter when the pool may not be inspected for long periods. It is, therefore, advisable to have the pool enclosed the year around. Where a permanent fence is not used, a temporary fence may easily be erected by placing fixtures in the walks close to the pool for the insertion of steel posts. With small pools, particularly at country clubs, it is a simple task to insert these posts each night and attach one or two ropes to guard the pool when no one is in attendance.

Lighting

A good lighting system adds much to the attractiveness of a pool and increases its hours of usefulness. Frequently a pool is used more in the evening than during the rest of the day. All pools used at night should have the entire pool enclosure well lighted. In addition to the required overhead lights for general illumination, underwater lights add appreciably to the attractiveness and safety of the pool.

There are several types of both overhead and underwater lights. The selection of the best types and their location to give the correct illumination at all points requires the services of a lighting specialist. Overhead lights should not be placed close to the pool since they attract bugs which would fall into the pool and onto the walks.

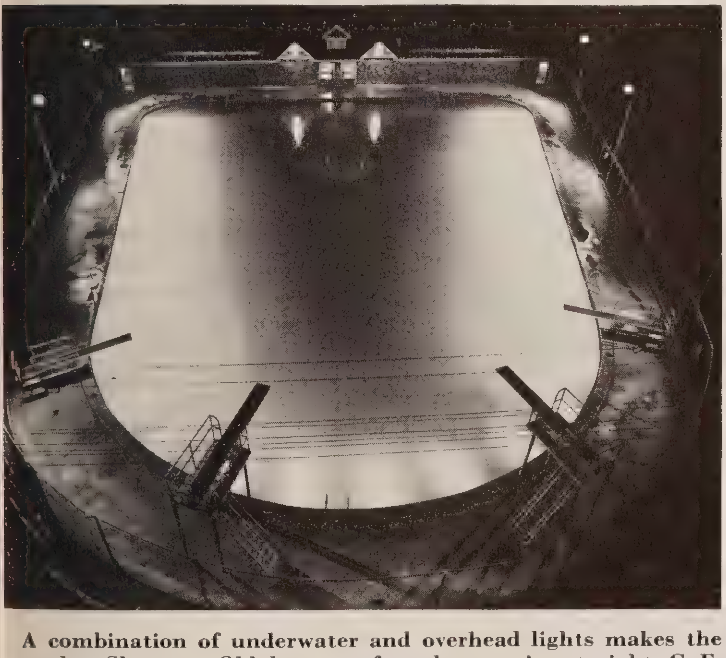
Underwater lights should be installed so that they may be serviced without emptying the pool.

Indoor Pools

It has been quite common practice to locate indoor pools in the basement because of saving in construction costs, even though it was more desirable to have them in the top story where windows and skylights allowed better ventilation and an abundance of sunlight. These latter considerations have lost much of their importance with increased use of mechanical ventilation and development of lamps with therapeutic properties.

Two of the biggest problems in connection with indoor pools are condensation and acoustics. The air in the room has a high moisture content which will cause condensation on walls and ceiling having a lower temperature. This trouble may be minimized by adequate ventilation and insulation of walls and ceiling. Fairly rapid changes of air will reduce the moisture content. The temperature differential between air, walls and ceiling may be reduced by keeping the room temperature as low as possible without discomfort to the bathers and by insulating the walls and ceiling, particularly exterior walls and roofs.

Most rooms for indoor pools are notoriously bad acoustically, since practically all ordinary room surfaces and equipment are highly sound reflective. It is, therefore, advisable to reduce the sound reflection from the walls and ceiling as much as possible by using sound-absorbing material. Breaking up the ceiling area with beams will also reduce reverberation.



A combination of underwater and overhead lights makes the pool at Shawnee, Oklahoma, safe and attractive at night. C. E. Edge, engineer.

Separation of diving, swimming and wading areas is desirable for safety. Cazenovia Park, Buffalo, has three pools completely separated by fencing. Placing the ladders across the pool from the diving boards practically eliminates diving accidents and decreases time between dives. Roeder J. Kinkel, architect.

Except with the best ventilation, temperature control and insulation, there will probably be some condensation. Unfortunately, most acoustical materials are affected by moisture so that great care must be taken in selecting them. Precast concrete units made with lightweight aggregates have considerable sound-absorbing value and will not deteriorate but rather grow stronger in the presence of moisture. Any color scheme may be obtained by painting with portland cement paint, and acoustical properties will not be materially reduced. Interesting architectural effects may be obtained by use of different-sized units. It is generally advisable to sacrifice acoustical properties on the walls for a height of 5 or 6 ft. and to use a smooth finish such as cast stone, glazed tile or enamel, which will not be affected by body contact.

Because of the noise and difficult acoustical conditions, swimming coaches have found microphones and loud speakers of considerable assistance.

Lighting of indoor pools should be arranged to eliminate glare. Underwater lights may be used here as well as in outdoor pools, although the greater intensity of general illumination reduces their advantage.

The minimum ceiling height will be governed by the diving equipment contemplated. There should be no obstructions within a radius of about 13 ft. from the end of the springboard.

Sanitation

The construction and operation of a modern swimming pool is a sanitary engineering problem. The design and equipment should be, and in many states must be, approved by the local and state health officials before construction is started.

From the standpoint of water supply, there are three general classifications of pools: fill-and-draw, flow-through, and recirculation.

In the old "fill-and-draw" system, the pool is completely emptied and refilled with fresh water at intervals. Between refillings the water may be intermittently disinfected and chemically corrected. A commercial sodium hypochlorite solution is most commonly used for this purpose. This system is not recommended for public pools and most health authorities will not permit its use in new pools. The cost of the fresh water for refilling is usually considerably more than the cost of recirculation. Heating the fresh supply to a satisfactory temperature for bathing, particularly in the

spring and fall, is also an item of considerable expense. In addition the pool will be out of service a considerable portion of the time while water is being changed.

With the "flow-through" system, there is a continuous flow of fresh water into the pool and a corresponding overflow. It is wise and sometimes necessary to add a chemical which will provide an adequate residual disinfectant. This system may be used satisfactorily where there is an adequate natural flow of pure water. Even where the water must be pumped, this system may be economical for private or semiprivate pools where the discharged water can be used for other purposes such as watering lawns. The temperature cannot be readily controlled.

Most of the pools built today use the recirculation system in which water is continuously drawn from the pool, passed through filters and other purification equipment, and then returned to the pool. This system requires only sufficient fresh water to make up for that lost by evaporation and through the overflows where the latter drain to the sewer. A minimum of heat is required to keep the water at the proper temperature. In fact, after outdoor pools have reached the proper temperature, there is more difficulty in keeping the water cool than in keeping it warm.

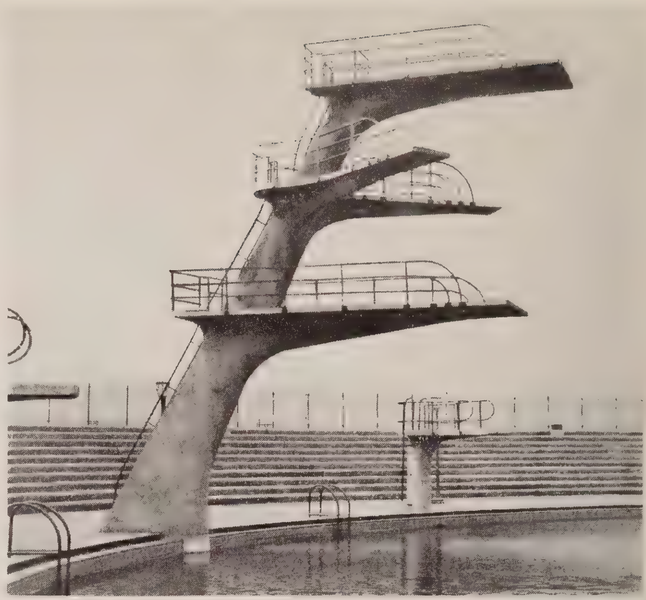
In recirculation pools the water usually enters through inlets near the top of the walls and is withdrawn through one or more outlets at the deepest point in the pool. The Joint Committee recommends that the inlets in rectangular pools be placed across the shallow end so that each inlet serves not more than 15 ft. of width. For all except the smallest pools, it is advisable to have a small amount of water enter at the deep end also. For pools exceeding about 35x75, it is desirable to have inlets on the sides as well as the ends. For large pools with outlets at the center, inlets should be placed around the entire perimeter. Where a rectangular pool without a hopper bottom is more than 20 ft. wide, multiple outlets should be provided, spaced not more than 20 ft. apart. They should be covered with a grating and the area should be sufficient to reduce the suction to a safe point. The inlets and outlets should be so arranged that all the water will be moving and there will be no "dead spots".

The so-called "closed system" is now gaining favor in certain parts of the country. In this system, drainage through the overflow is returned to the filter. In many of these pools the discharge from the main drain is controlled so that there is a considerable overflow which removes surface dirt and keeps overflows clean.

In still another new system, sometimes called the "reverse flow", the water enters at the bottom of the pool and is all drawn off through the overflows.

Filtration removes from the water all suspended matter and a portion of the bacteria. There are several types of filters in use for the purification of water in swimming pools. The most common is the pressure filter, which occupies a comparatively small space, is relatively simple to operate, and gives excellent results.

The diatomaceous earth type of filter so widely used by our armed forces is becoming popular for swimming pools. It is compact, easy to operate and relatively low in cost.



Diving towers such as these at Astoria Park are used by the New York City Department of Parks.

The gravity sand filter, used in many water supply systems, is also frequently used for swimming pools. When properly designed, this type of filter is efficient, easy to operate, and economical in construction, particularly for large pools.

Most health authorities recommend that the pumps and filters be large enough to recirculate the entire content of the pool in 8 hours or less.

The filtration process returns the water to the pool in a clear, sparkling condition, free from turbidity and suspended matter, as well as a portion of the original bacteria content. In order to have a water free from all disease-producing bacteria, a germicidal treatment of the water is necessary in addition to filtration. Several disinfecting agents have been used, including chlorine, bromine, ultra-violet light, ozone, and colloidal silver.

At present chlorine is used almost exclusively but the use of bromine is increasing. Chlorine may be used in the form of gas compressed to a liquid, sodium hypochlorite or calcium hypochlorite. Sodium hypochlorite may be formed at the pool by electrolysis of a solution of common salt. The use of ammonia with chlorine has some benefits. Adding chlorine before filtration will require the use of a slightly greater amount, but will aid in keeping the filters in good condition and prevent growth of bacteria on them.

Algae, which form either a greenish or brownish cloud in the water or form a slippery coating on walls or floors, often appear in outdoor pools. Maintenance of the standard chlorine residual will assist greatly in preventing algae. Energetic control measures should be undertaken immediately upon the first signs of algae. Treatment with copper sulphate is the most common method, but other forms of copper, particularly colloidal copper, are being used. Superchlorination is rapidly gaining favor as a control for algae. With this treatment a large excess of chlorine is added when the pool closes at night. The next day the excess will have been dissipated so that the pool can be used.

The amount of copper sulphate required will vary greatly, depending upon many things including the type of algae and the water purification system. Ordinarily about 5 to 20 lb. per 1,000,000 gal. will be satisfactory. In severe cases it may be necessary to drain the pool and scrub walls, floor and walks with strong copper sulphate or sodium hypochlorite solution.

The copper sulphate may be applied through a treatment tank, by dragging through the water a sack or perforated can filled with crystals, or by sprinkling a strong solution over the top of the water and then agitating it violently.

"Athlete's foot", a fungus growth similar to ringworm, is now receiving serious attention at all well-operated swimming pools. Every precaution should be taken to prevent its spread. The floors of the bathhouse and the pool walks should be washed and disinfected at least once daily. It is frequently required that foot baths containing a fungicidal solution be so placed that bathers must walk through them in going to and from the pool, but their effectiveness is open to serious question.

Every pool should have a suction cleaner as part of its equipment. Regardless of the efficiency of the water purification system and pool operation, dirt will accumulate on the bottom of the pool. The only satisfactory way of removing this is with a suction cleaner. There are several types which work satisfactorily. Some have permanent connections spaced around the pool to which the suction hose and cleaner may be attached as needed, the suction being obtained from the main water return line or from a special pump. Another type has a portable self-priming suction pump which may be pulled around the edge of the pool.

A very important piece of operating equipment which is sometimes overlooked is the hair and lint catcher, which should be installed in the suction line of all recirculating systems. It will remove hair, lint and other small solid wastes from the water and thus protect the pumps and filters. The hair catcher must be readily accessible and it is advisable to use one which is extra large and easily changed.

Water and sewer connections must be so made that there is no possibility of reverse flow from the pool to the water supply system or from the sewer to the pool. Most state health departments require a broken connection between the original water supply and the recirculating system, accomplished by using an open surge tank with the original water outlet at least 6 in. above the tank. The new water should pass through the filter before entering the pool so that any suspended matter will be removed.

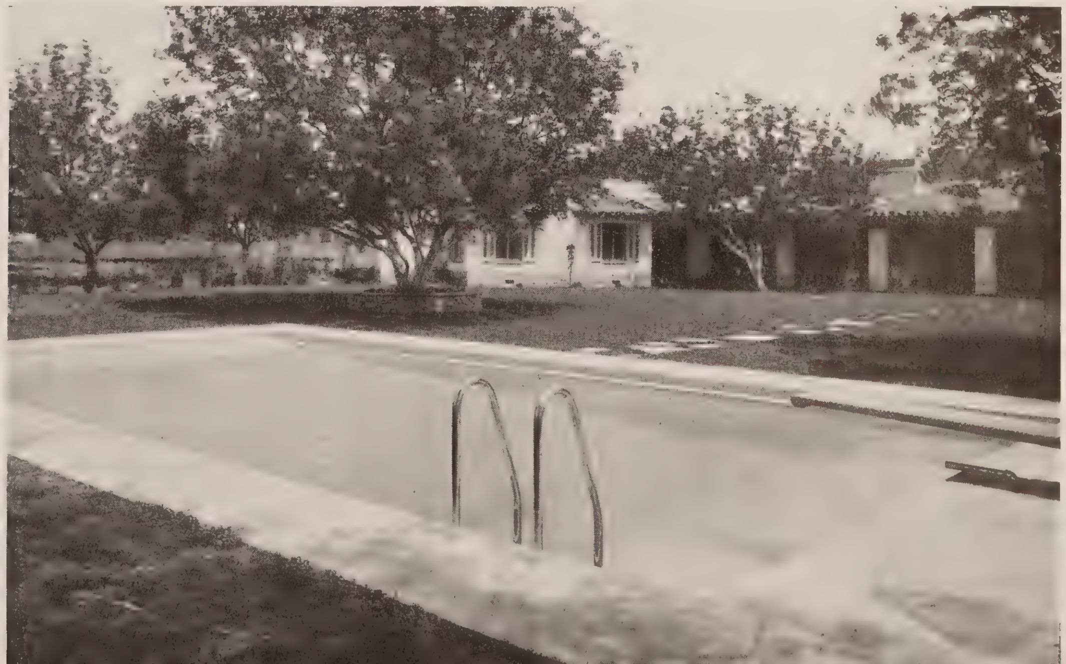
Amusement Equipment

Pool equipment may include springboards, diving towers, chutes and floats. Safety should be the most important consideration in both the selection and installation of equipment.

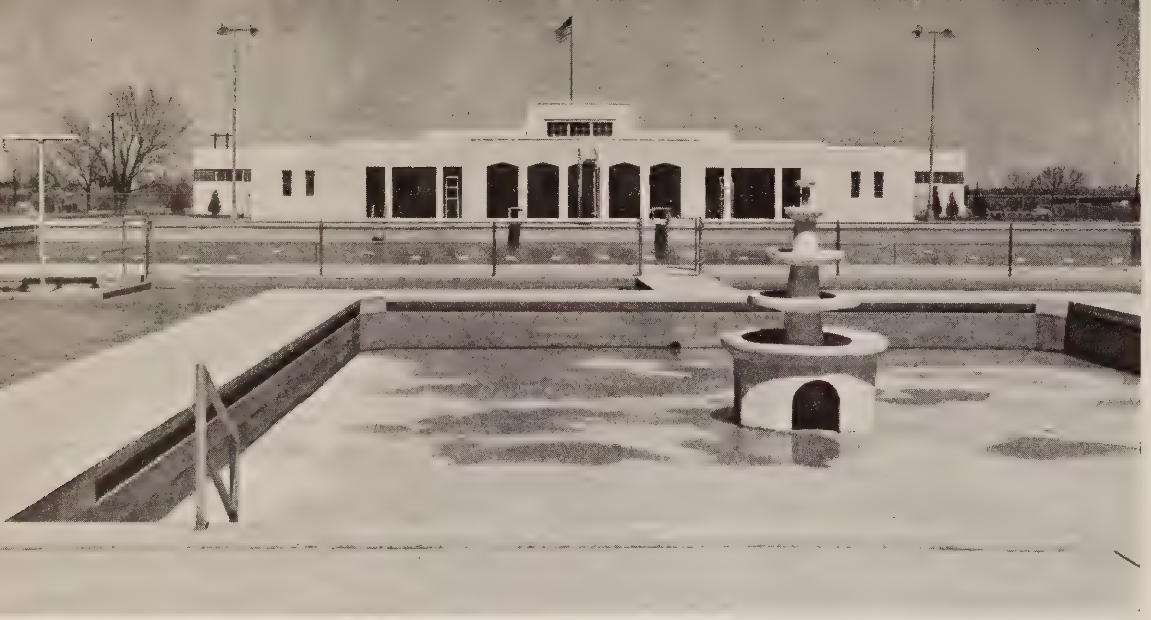
Many bathers, more interested in diving than swimming, are attracted to the swimming pool by the springboards and diving platforms. A standard diving board will be found more satisfactory and economical than a makeshift board. Furthermore, if diving contests are held under standard regulations, the board must be constructed and installed in accordance with the specifications of the National Collegiate Athletic Association and the Amateur Athletic Union.

Diving platforms placed at the regulation heights, provided a sufficient depth of water is available, will be very popular among the better divers.

Springboards and diving platforms should be covered with cocoa fiber matting to prevent slipping. This material, being loosely woven, dries out quickly and thus preserves the board. If spare boards are kept on hand, they may be changed from time to time, permitting them to be refinished and covered, which will greatly prolong their usefulness.



An example of the simple private pool is this one at the home of Seton I. Miller, Van Nuys, California. Charles O. Matcham and Paul O. Davis, architects.



This development at Marshall, Missouri, includes an architectural concrete bathhouse, swimming and diving pool, wading pool and sand beach. Note the shower between the sand beach and the swimming pool. R. N. Perkins, architect.

Chutes or slides, properly constructed, are quite safe and furnish a real thrill. In small pools they are impractical, but where there is sufficient space they contribute greatly to the popularity of the pool.

The greater part of time spent in the water is devoted to play rather than to actual swimming, so that play equipment, such as floats, inflated rubber horses, frogs, and fish, will be found very useful and comparatively inexpensive.

SPECTATOR FACILITIES

The financial success of a pool depends upon public interest which will create patronage. Interest may be greatly enhanced by adequate provisions for spectators, for whom separate seating and toilet facilities should be provided. The latter can be located in the bathhouse but should be so arranged that the spectators and bathers are completely separated at all times.

Where funds are available, it is wise to build permanent spectator galleries or bleachers which require no upkeep other than sweeping or flushing with a hose. The actual seats may be anything from the plain board seats of the usual bleachers to movable chairs. The seats should be on the west or south side of the pool so that the spectators will not face the sun and should preferably be parallel to the diving boards. Where the bathhouse has a flat roof, provision can easily be made for using this space for spectators.

Many pools obtain additional direct revenue by charging a nominal admission to the spectators' gallery.

BATHHOUSES

The bathhouse is an integral and important part of the outdoor swimming pool and should be designed to harmonize with the pool and its surroundings.

The first impression a patron receives as he arrives and the last impression he has as he leaves is of the bathhouse, so it is very important that the bathhouse have the same atmosphere of cleanliness and sanitation as is built into the pool.

Location of the bathhouse with reference to the pool will depend upon the size of the pool and the space available. However, when possible, they should be arranged so that the bathhouse will protect the pool from the prevailing winds. It should be placed along the side of the pool or preferably at the shallow end in order to reduce the danger of poor swimmers and children jumping into the deep water.

The capacity and operation of the bathhouse must be such as to avoid overcrowding at times of maximum demand. However, as with the pool itself, it is better to have an overcrowded condition a few times a year than to have facilities so large as to be uneconomical most of the time.

Size and Equipment

Some of the many factors affecting the size of the bathhouse in relation to the size of pool are: lockers or central checking system; individual dressing rooms or dormitory system; private or group showers; and extra facilities. If privately-owned suits are allowed, some patrons will come to the pool all ready to swim, so that the size of dressing and check rooms may be reduced; but since all bathers should be required to take a cleansing shower, the number of showers should remain the same.

An investigation of several pools shows that the area of the bathhouse averages about one-third the area of the pool, which is fairly comparable to the suggestion that the area of dressing rooms be about one-fifth the area of the pool.

The Joint Committee recommends bathhouse facilities be provided as shown below, based on the number of bathers present at any one time, two-thirds of whom may be assumed to be men:

1 shower for each 40 bathers.
1 lavatory for each 60 bathers.
1 toilet for each 40 women.
1 toilet for each 60 men.
1 urinal for each 60 men.

Arrangement

Very often the financial success of a pool depends upon the arrangement of the bathhouse. The entire project should be so planned that the pool and bathhouse can be operated with a minimum personnel, particularly during slack periods.

Manager's office, first aid room, cashier, suit and towel rooms, and check room for valuables should be in the center of the building. The wings at either end of the building may house lockers, dressing rooms, toilets and showers, those for men being located on one side and those for women on the opposite side of the lobby.

All facilities should be so arranged that patrons can pass through quickly without confusion. The only route from the dressing room to the pool should be past the toilet and shower rooms. Each patron should be required to take a thorough cleansing shower with soap before putting on a bathing suit. An adequate supply of warm water must be provided. By requiring each bather to pass through a group of showers before entering the pool, at least a superficial bath will be obtained but this should not be considered as replacing the required shower in the nude.

It is desirable for bathers returning from the pool to pass through a separate drying room to the dressing room, and for the "wet" and "dry" bathers to be separated as much as practicable. The exit from the bathhouse to the street should be so arranged that an attendant may collect all keys, checks, suits or other supplies belonging to the establishment.

Toilets should be accessible directly from both the dressing room and pool. Separate ones for wet and dry bathers are very desirable. The wall-hung prison type of fixtures are the best. Disinfecting foot baths should be placed between the pool and the toilet.

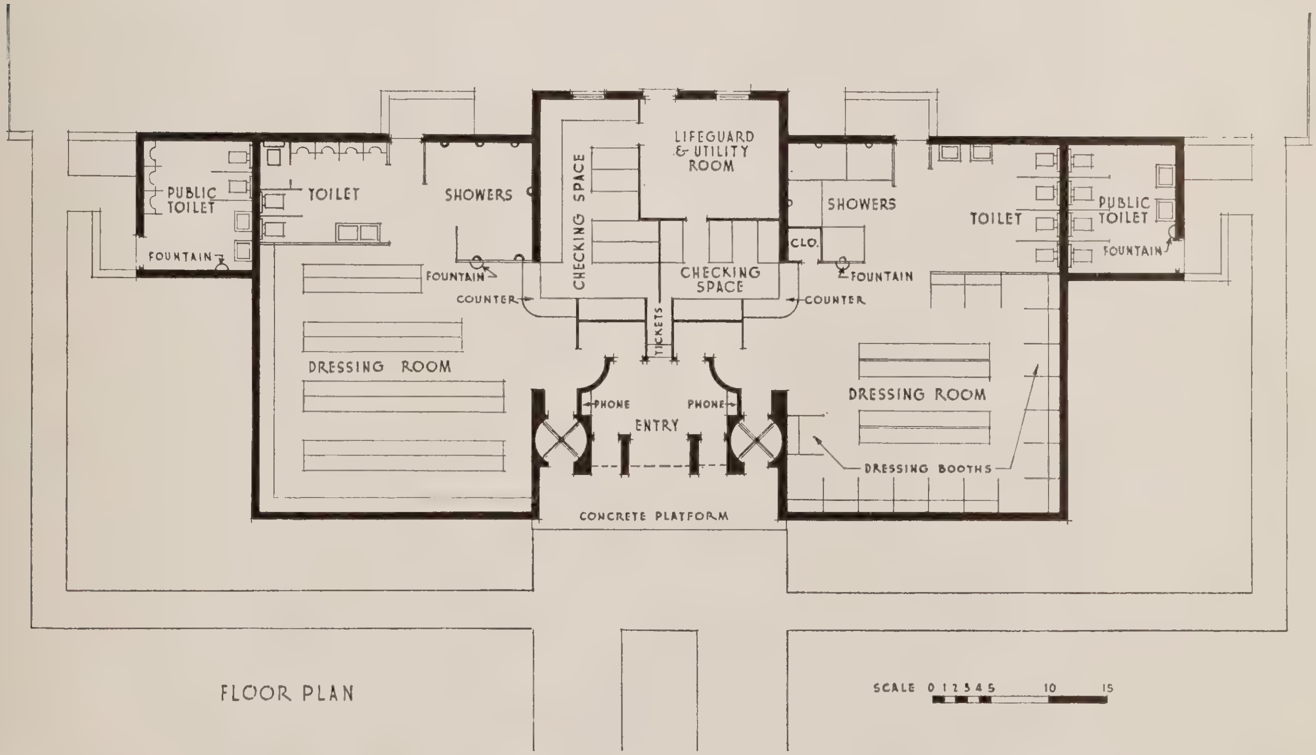
Floors of bathhouses should be pitched about ¼ in. per ft. to frequent outlets to assure rapid drainage. There should be an ample number of hose connections to make cleaning easy. Not less than 1-in. hose should be used so that there will be adequate water volume and pressure.

Dressing Room Facilities

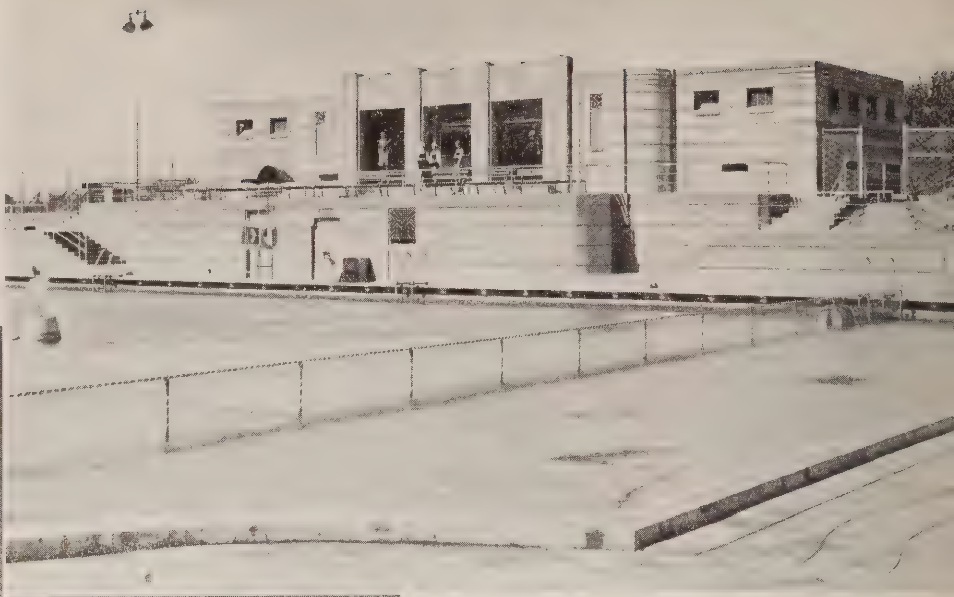
The method of clothes checking must be determined before the bathhouse layout can be made, as the method will vitally affect the entire arrangement.

Both individual lockers and baskets or bags checked in a central room have been used successfully for the storage of clothing, the choice between the two depending mainly upon local conditions. A combination of the two systems is possibly the most desirable since obviously the requirements for a well-dressed adult and a boy in play clothes are not the same. Lockers should be placed on a raised platform to keep them dry and to simplify cleaning the floor. Lockers are more costly and require more space, but tend to keep the clothes in better condition.

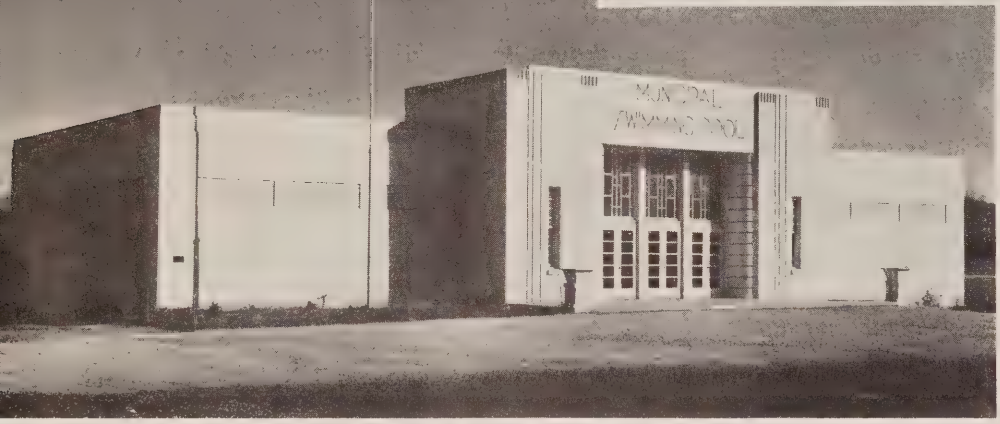
Individual dressing rooms are generally provided for women and girls, whereas men and boys will usually



Suggested layout for a bathhouse with a capacity of 340 persons corresponding to a 40 x 100-ft. pool.



This architectural concrete bathhouse at Kearney, Nebraska, forms an integral part of the pool development. A fence separates wading and swimming areas. McClure and Walker, architects.



The simple, clean lines of this architectural concrete bathhouse at Dubuque, Iowa advertise the cleanliness of the swimming pool. C. I. Krajewski, architect.

dress in the aisles between rows of benches or lockers. A few individual dressing rooms are sometimes provided in the men's section.

Regardless of the system adopted, dressing and locker rooms should be arranged to permit a maximum of sunlight and air. A bright, airy dressing room will do much toward maintaining it in a clean, sanitary condition.

Both individually and group-controlled showers are in general use. Control and operation of each group vary and all have advantages and disadvantages. However, all modern equipment has some type of control so that there is no possibility of bathers being scalded.

There are many kinds of bathhouse equipment on the market which add to the convenience of the patrons and increase the popularity of the pool. The hair dryer is practically a necessity for the women bathers. Comb-vending machines, exercisers and scales are frequently installed by the most up-to-date pool operators.

Construction

The particular use of the bathhouse requires consideration of special properties as well as the usual ones in the selection of construction materials. Some of the principal considerations are: architectural effect, cost, resistance to deterioration and fire, ease and cost of maintenance, and water resistance.

The bathhouse, being an integral part of the pool development, should harmonize architecturally with the pool. It should give the impression of cleanliness, safety and happiness.

Resistance to deterioration and fire is especially important in bathhouses. The dampness always prevailing is particularly harmful to some materials and causes rapid deterioration. Materials which are entirely satisfactory in ordinary buildings cannot be used for bathhouses. During a considerable portion of the year, the bathhouse is without attendants and is generally in an isolated location and thus subject to vandals. A fire starting under such conditions could gain considerable headway before detection.

Bathhouses must be kept scrupulously clean. The easiest and most satisfactory way of doing this is by frequent washing. The construction should be such that washing may be done with a high-pressure hose without damage to the building.

Architectural concrete* meets all these requirements admirably. Being of the same material as the pool, it

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*Additional information is contained in *Architectural Concrete for Small Buildings.*

gives the natural impression of being part of the development. Its clear-cut lines symbolize cleanliness, strength and safety. The inside may be left exposed without any treatment except possibly painting. This reduces the original cost, the possibility of deterioration from any cause and makes the building easy to clean with a hose. Such a structure is highly fire-resistant and vandals can do little damage to it.

Hollow concrete masonry units* also are an admirable material for bathhouses. The walls may be simply painted or may be covered with portland cement stucco* on the outside and portland cement plaster on the inside. When the units are laid in a random ashlar pattern, particularly interesting architectural effects may be obtained. Here again the material is economical in first cost, is very resistant to deterioration and fire, is easy and economical to maintain, and is not affected by moisture. In addition, the units made with lightweight aggregates have good acoustical properties.

Quite satisfactory results have been obtained from the open court type of bathhouse in which the roof is omitted over part of the dressing room area. The abundance of sunshine and air thus admitted to the dressing areas helps to keep them in a sanitary condition. There is also some saving in original cost.

Equipment Room

The room for mechanical equipment must be of adequate size to permit easy access to all equipment both for usual operation and for necessary repairs. There should be easy access to the room to encourage rather than discourage frequent attention to equipment. Adequate ventilation is important to prevent deterioration of equipment. Floors should be pitched about ½ in. per ft. to frequent drains or to gutters.

OPERATION

A swimming pool must be intelligently operated to be a success. This requires not only an efficient and dynamic manager, but also an intelligent, trained personnel. At least one lifeguard should be at the side of the pool at all times when swimming is permitted. This lifeguard should be not only an expert swimmer, but should also be trained in lifesaving, resuscitation and first aid. Lifesaving and first aid equipment should always be available. Attendants should wear uniforms or some identification indicating their authority to enforce rules.

The public demands and will pay for good service. All employes should understand this. The arrangement of the pool and bathhouse and the selection and training of the personnel should be such that the operation is flexible enough to manage the pool efficiently with a small force during slack periods and a larger force during rush periods. The bathers should be under supervision from the time they buy their ticket until they leave the premises.

Regulations are necessary to insure sanitary conditions and to maintain order, but they should be as few and simple as required to obtain the desired results. Once regulations are established they should be quietly but strictly enforced. Posting these rules in conspicuous and appropriate places will aid in their enforcement. The posters should contain headline phrases in large letters. Using a series of educational posters will help materially in gaining the patrons' cooperation in the enforcement of the rules.

The smart operator recognizes the importance of perfect cleanliness, both real and apparent. Because light-colored materials show dirt easily, they force the operator to keep them clean, and they impress the public with the cleanliness of the establishment. Each morning the suction cleaner should be used to remove any dirt from the bottom of the pool, and any floating

At Crotona Park, New York City, one attendant can handle clothes checking and closely supervise dressing room during slack periods, while additional attendants can work efficiently during rush periods. Designed by Department of Parks.

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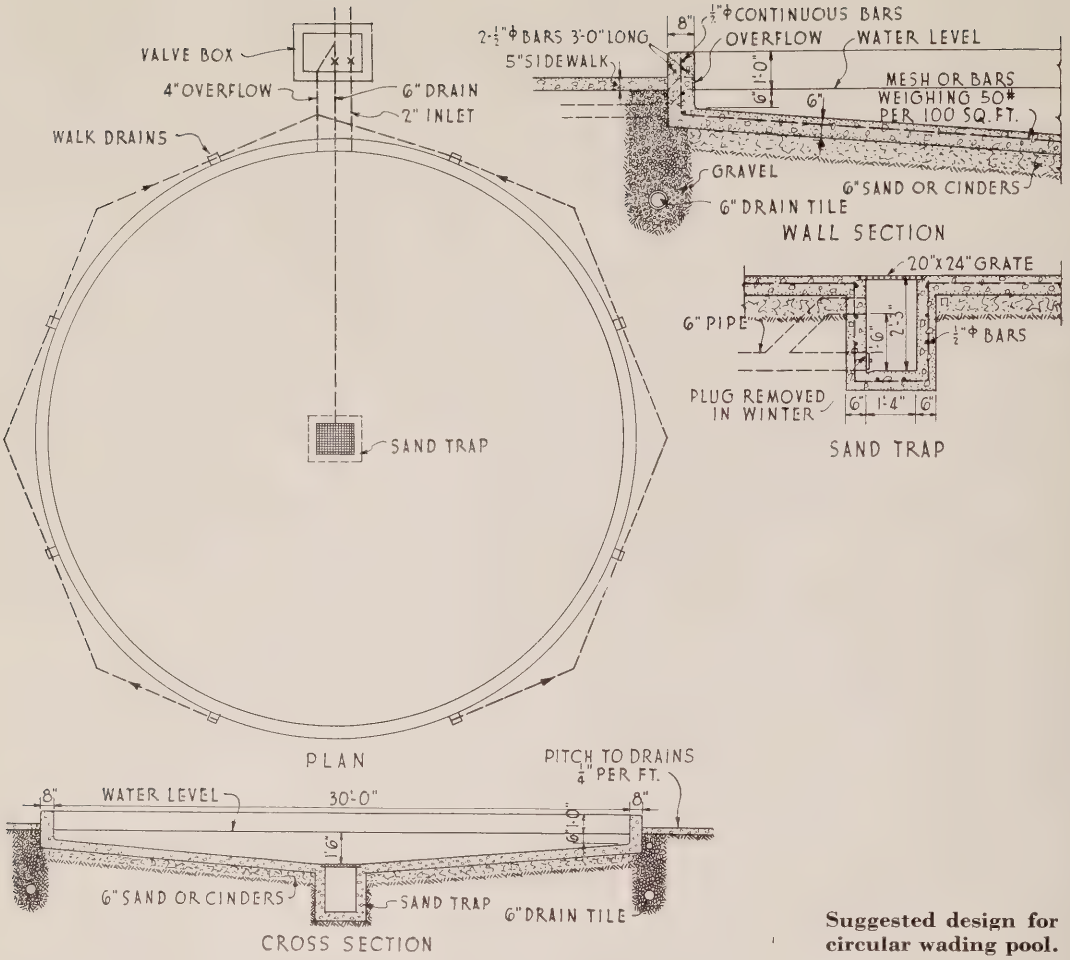
*Additional information is contained in *Facts About Concrete Masonry* and *Plasterer's Manual.*



Suggested design for circular wading pool.

debris should be removed by skimming or overflowing. The walks and the floors of the bathhouse should also be washed daily and waste paper and rubbish collected as frequently as necessary during the day.

All mechanical equipment requires some attention. The manufacturers give instructions for the proper operation of their equipment. The instructions should be posted near the equipment and carefully followed. All equipment should be thoroughly checked enough in advance of the opening of the season to have any necessary repairs made.

Expansion joints must be renewed occasionally. They should all be carefully inspected before the season opens, and new material added where required. It will sometimes be necessary to remove the old material and completely replace it.

One of the important jobs of the manager of a successful pool is to create and maintain interest in swimming. This may be done in several ways, including sponsoring "learn to swim" campaigns, instruction in lifesaving, competitive games and exhibitions.

REVENUE

When studying operating expenses and incomes from swimming pools, consideration must be given to the purpose for which the pool is operated. Many pools, the same as other park facilities, are operated primarily as a health and recreational service to the community. While there are some pools which are entirely free to the public, a charge is made for the use of most of them. These charges are established to pay part of the expense, to pay the entire expense or to make a profit.

In determining the charges, special consideration should always be given to the children. Interesting them in swimming will increase general interest in the pool and will also build future patronage. During the morning, at least, children should be admitted free or for a very nominal fee.

For public pools admission charges vary from nothing to $1 for adults, and from nothing to 50c for children, but the common range is from 25c to 50c for adults and 10c to 25c for children, with special rates for children during certain hours. Season tickets vary from 10 to 30 times the cost of a single admission, 20 times being most common. At some pools, season tickets for the entire family are available at only a slight increase over the cost of individual season tickets.

The financial success of a pool depends in a large part upon the standards and methods of operation.

WADING POOLS

Some outdoor public swimming pools are designed with a section to be used as a wading pool. However, the depth of water at the shallow end of such pools is often greater than is safe for small children unable to swim. Even when the shallow end is such as to be satisfactory for wading, there is always possible danger of small children venturing too far into deep water, where they are soon in trouble unless help comes quickly. The occasional contamination, unavoidable with small children, is very undesirable in the main pool. For these reasons, wading pools should preferably be made as independent structures. Where constructed as part of the swimming pool, the wading area, including walks, should be set apart by a fence.

Two or more small pools are much better than one large pool. If the small pools can be located in different parts of the city, it is still better. Small areas not suitable for swimming pools can often be utilized for wading pools. School grounds and small city playgrounds as well as public parks may be used. Wading pools do not require bathhouses.

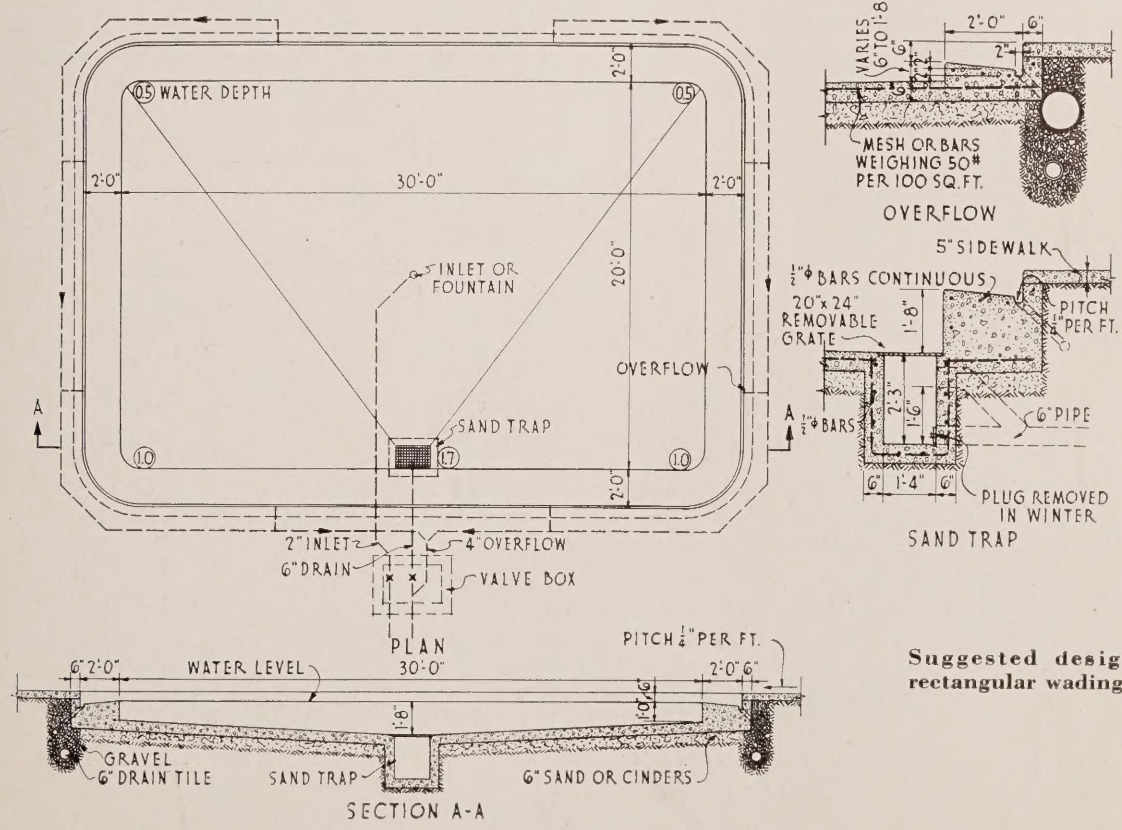
The floor of the pool may slope gradually to above the water line or may have a low curb around it, giving a water depth of about 6 in. The maximum depth should not be more than about 24 in. The bottom slope must be very gradual, not more than 1 to 15.

The wading pool at Benson Playground is one of several for children of Omaha, Neb. E. M. Rohrbough, designer.

With wading pools, the quantity of water is small, the contamination high and a considerable amount of sand and debris is carried into the pool so that it is not advisable to recirculate the water. The fill-and-draw system is frequently used, but the flow-through system is preferable, particularly where the load is heavy. Even with the flow-through system it is advisable to drain and clean the pool each night.

Because of the large amount of sand and other debris carried into a wading pool, it is necessary to provide simple, accessible sand traps in the drainage system. Showers or fountain sprays are always enjoyed by the children and may be used as the water inlet. Some health authorities are strongly urging that fountain sprays be used without retaining an appreciable amount of water in the pool.

A sand play beach is a big addition to a wading pool. However, the sand must be frequently screened to its entire depth and thoroughly disinfected. Several times a day it should be raked and sprinkled with a disinfectant. A concrete slab provided with frequent drains, underlying the sand, will aid materially in keeping the sand in a sanitary condition.



Suggested design for rectangular wading pool.

CONCRETE SPECIFICATIONS FOR SWIMMING POOLS

1. Portland Cement

Portland cement shall conform to the "Standard Specifications for Portland Cement" (A.S.T.M. Serial Designation: C150) †and shall be Type————.

These specifications cover five types of portland cement as follows and provide that "when no type is specified, the requirements of Type I shall govern"*.

"Type I.—For use in general concrete construction when the special properties specified for Types II, III, IV and V are not required.

"Type II.—For use in general concrete construction exposed to moderate sulfate action, or where moderate heat of hydration is required.

"Type III.—For use when high early strength is required.

"Type IV.—For use when a low heat of hydration is required (*see Note*).

"Type V.—For use when high sulfate resistance is required (*see Note*).

"*Note—Attention is called to the fact that cements conforming to the requirements for Type IV and Type V are not usually carried in stock. In advance of specifying their use, purchasers or their representatives should determine whether these types of cement are or can be made available.*"

**These paragraphs including Note are quoted from above specifications.*

2. Fine Aggregate

Fine aggregate shall consist of sand having clean, hard, durable, uncoated grains, free from deleterious substances.

Fine aggregate shall range in size from fine to coarse within the following percentages by weight:

Passing No. 4 sieve	95 to 100 per cent
Passing No. 16 sieve	45 to 70 per cent
Passing No. 50 sieve	15 to 30 per cent
Passing No. 100 sieve	3 to 8 per cent
Volume removed by sedimentation	Not more than 3 per cent

3. Coarse Aggregate

Coarse aggregate shall consist of crushed stone, gravel, or other approved inert materials with similar characteristics or combinations thereof, having clean, hard, durable, uncoated particles, free from deleterious matter.

Coarse aggregate shall range in size from fine to coarse within the following percentages by weight:

Passing 1½-in. sieve	95 to 100 per cent
Passing ¾-in. sieve	35 to 70 per cent
Passing ⅜-in. sieve	10 to 30 per cent
Passing No. 4 sieve	0 to 5 per cent

Bank or pit-run aggregate in its original state shall not be used.

4. Mixing Water

Mixing water shall be free from oil, acid, and injurious amounts of vegetable matter, alkalies or other salts.

5. Reinforcement

Reinforcement shall conform to the American Society for Testing Materials specifications for reinforcement bars of intermediate grade billet or axle steel or rail steel or for cold drawn wire.

6. Measuring Ingredients

Aggregates shall be measured separately by weight or volume. Water shall be so measured as to insure the desired quantity in successive batches.

7. Water-Cement Ratio

The proportioning of materials shall be based on the requirements of a plastic and workable mix containing not more than 6 gal. of water per sack (94 lb.) of cement. This quantity of water must not be exceeded. Water in the aggregate must be included in quantity specified and subtracted from amount added to mix.

8. Moisture in Aggregate

Moisture in the aggregate shall be measured by methods satisfactory to the engineer which will give results within 1 lb. for each 100 lb. of aggregate.

9. Workability

The mixture shall produce concrete that can be worked readily into corners and angles of the forms and around the reinforcement without excessive spading or separation of materials.

In no case shall more than 1 part of fine aggregate be used to 1 part of coarse aggregate nor shall the amount of coarse aggregate be such as to produce harshness in placing or honeycombing.

10. Trial Batches

Full-sized trial batches shall be made in the mixer, using the aggregates selected for the job to establish the correct proportions to give proper workability with the water-cement ratio specified††. The combination of fine and coarse aggregates shall be adjusted within limits specified until mix meets approval of the engineer.

11. Mixing

Concrete shall be mixed in a batch mixer until there is a uniform distribution of materials. The entire contents of the drum shall be discharged before recharging. The volume of the mixed material per batch shall not exceed the manufacturer's rated capacity of the mixer. The mixer shall be operated at the speed recommended by the manufacturer. Mixing of each batch shall continue not less than 1 minute after all materials, including water, are in mixer.

12. Retempering

Retempering of concrete which has partially hardened, that is, remixing with or without additional cement, aggregate, or water, will not be permitted.

13. Depositing

Before depositing any concrete, all debris shall be removed from the space to be occupied by the concrete, all steel reinforcement shall be secured in its proper location, all forms shall be thoroughly wetted (except in freezing weather) or oiled, and all formwork and steel reinforcement shall be inspected and approved by the engineer.

Concrete shall be handled from the mixer to the place of final deposit by methods which shall prevent the separation or loss of ingredients and shall be deposited as nearly as practicable in its final position to avoid rehandling. It shall be deposited so as to maintain, until the completion of the unit, a plastic surface approximately horizontal. The concrete shall be placed in a manner that will avoid accumulation of hardened concrete on the forms or reinforcement. Under no circumstances shall concrete that has partially hardened be deposited in the work.

14. Depositing Against Other Concrete

Before depositing new concrete on or against concrete that has hardened, forms shall be retightened, surface of the hardened concrete roughened as required, thoroughly cleaned of foreign matter and laitance, and moistened with water. The cleaned and moistened surface, including vertical and inclined surfaces, shall be slushed with a coating of neat portland cement grout against which the new concrete shall be placed before the grout has attained its initial set. Concrete for the first 6 in. of the new layer shall consist of a mix having one-half the amount of coarse aggregate in the regular mix.

15. Compacting

Concrete during and immediately after depositing shall be thoroughly compacted by means of suitable tools and shall be thoroughly worked around the reinforcement and embedded fixtures and into corners of the forms.

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†Where reference is made to A.S.T.M. standards and the year of adoption is not shown, the current standard shall apply.

††With average materials the first trial may be a mix of about 200-225 lb. of sand and 300-350 lb. of coarse aggregate per sack of cement.

16. Protecting and Curing

Exposed surfaces of concrete shall be protected from premature drying by methods approved by the engineer. All concrete shall be kept wet for not less than 7 days, except that 3 days shall be considered sufficient if high early strength portland cement or concrete is used.

17. Temperature

Concrete when deposited shall have a temperature not below 70 deg. F. and not above 80 deg. F. In freezing weather, suitable means shall be provided for maintaining the concrete at a temperature not lower than 70 deg. F. for 3 days or 50 deg. F. for 5 days after placing, except when high early strength portland cement or concrete is used the temperature shall be maintained not lower than 70 deg. F. for 2 days or 50 deg. F. for 3 days. The methods of heating materials and protecting concrete shall be approved by the engineer. Salt, chemicals or other foreign materials shall not be mixed with the concrete for the purpose of preventing freezing.

18. Patching

After removing forms and before the concrete is thoroughly dry, any poor joints, voids, stone pockets or other defective areas and all tie holes shall be patched. Defective areas shall be chipped away to a depth of not less than 1 in. with the edges perpendicular to the surface. The area to be patched and a space at least 6 in. wide entirely surrounding it shall be wetted to prevent absorption of water from the patching mortar. The patch shall be made of the same materials and proportions as used for the concrete, except that the coarse aggregate shall be omitted and white portland cement substituted for a part of the grey portland cement to match the color of the surrounding concrete. The amount of mixing water shall be as little as consistent with the requirements of handling and placing. The mortar shall be retempered without the addition of water by allowing it to stand for 1 hour, during which time it shall be mixed with a trowel to prevent setting.

The mortar shall be thoroughly compacted into place and screeded, leaving the patch slightly higher than the surrounding surface. After being undisturbed for 1 to 2 hours to permit initial shrinkage, the patch shall be finished to match the adjoining surface.

Tie holes left by withdrawal of rods or the holes left by removal of ends of ties shall be filled solid with mortar. For holes passing entirely through the wall, a plunger-type grease gun or other device shall be used to force mortar through the wall, starting at the back face. A piece of burlap or canvas shall be held over the hole on the exposed surface and when the hole is completely filled the excess mortar shall be struck off with the cloth flush with the surface. Holes not passing entirely through the wall shall be filled with a small tool that will permit packing the hole solid with mortar, any excess mortar being struck off flush with a cloth.

19. Wall Finish

The exposed wall surfaces shall be finished by wetting, thoroughly rubbing with a carborundum brick and rinsing. The top of the wall shall be finished as for walks.

20. Floor and Walk Finish

After the concrete has been brought to the established grade by means of a strikeboard, the screeds shall be removed and the space filled with concrete which is well worked into the adjacent slab. The concrete shall be floated with a wood float in a manner that will thoroughly compact it and provide a smooth, even surface. After the water sheen has disappeared the surface shall be lightly steel troweled, followed by a light brushing with a hair brush or other approved treatment to give a non-slip finish.

Note: If a dusted-on color finish for the pool floor is desired, add paragraph 20(a):

20(a). Dusted-on Finish

The dusted-on mixture shall consist of 1 part portland cement, 1 to 1½ parts of dry aggregate and the required amount of color. All materials shall be proportioned by weight and the same amounts used in each batch. The materials shall be mixed dry in an approved mixing machine or mortar box until the color is uniform. After the base concrete has been screeded and the surface water removed, the dusted-on mixture shall be uniformly spread at the rate of not less than 125 lb. per 100 sq. ft. of area. The dry material shall be floated and worked into the slab, the first floating being stopped as soon as the surface becomes wet and the second floating withheld until surface moisture has disappeared. After the final floating, the surface shall be tested with a straightedge and high or low spots eliminated. Steel troweling shall be delayed until water sheen has disappeared.

21. Forms

Forms shall conform to the shape, lines, and dimensions of the concrete as shown on the plans. Lumber used in the forms for exposed surfaces shall be dressed to a uniform thickness, and shall be free from loose knots or other defects. Joints in forms shall be horizontal or vertical. For unexposed surfaces, rough lumber may be used. Lumber once used in forms shall have nails withdrawn and surfaces to be in contact with concrete thoroughly cleaned before being used again.

22. Cleaning Reinforcement

Metal reinforcement at the time concrete is placed shall be free from rust scale or other coatings that will destroy or reduce the bond. Where there is delay in depositing concrete, reinforcement shall be reinspected and, when necessary, cleaned.

23. Bending

Reinforcement shall be carefully formed to the dimensions indicated on the plans. Bends shall be made around a pin having a diameter of 6 or more times the least dimension of the reinforcement. Reinforcement shall not be bent or straightened in a manner that will injure the material. Bars with kinks or bends not shown in the plans shall not be used. Heating of reinforcement will be permitted only when approved by the engineer.

24. Placing Reinforcement

Metal reinforcement shall be accurately positioned and secured against displacement by using annealed iron wire of not less than 16 gage or suitable clips at intersections, and shall be supported in a manner that will keep all metal away from the exposed surfaces. The minimum clear distance between any bar and the nearest concrete face shall not be less than 2 in., unless specifically shown on the plans.

Wire mesh used in the floor slab shall be lapped not less than 6 in. on all sides and securely wired.

Wherever it is necessary to splice reinforcement otherwise than as shown in the plans, the character of the splice shall be decided by the engineer on the basis of safe bond stress and the stress in the reinforcement at the splice.

25. Construction Joints

When necessary to provide construction joints not indicated on the plans, such joints shall be located and formed so as not to impair strength, watertightness or appearance of structure.

26. Expansion Joints

Expansion joints in the floor and walls shall be spaced not over 60 ft. apart. The joints shall be filled with an approved material which will not run in hot weather nor become brittle when cold nor be affected adversely by water. The wall joints shall be provided with a crimped copper strip to serve as a water stop. Special types of joints and joint fillers may be used when approved by the engineer.

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